Winter, 1976

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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(Cover picture by Larry Baker)

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After 100 years of cropping . . .

The baskets contain part of the hundredth harvest from the Morrow Plots. Corn on left represents 49 bushels per acre harvested from a plot where corn has been grown continuously without soil treatment since 1876. Corn on right represents a yield of 191 bushels from a plot which has been in a two-year rotation from the beginning and which has been receiving a high level of fertility since 1967. Standing by the baskets are Laura Bateman, student, and L. F. Welch, co-author of the article on the following pages.

Lessons From the Morrow Plots

L. F. WELCH, S. W. MELSTED, and M. G. OLDHAM

AG RESEARCH: THE FIRST 100 YEARS OF FOREVER

WHILE the United States is recognizing its bicentennial year, the Morrow Plots have reached their centennial year. After 100 years of cropping, valuable lessons have been learned from America's oldest soil research plots, located on the University of Illinois campus in Urbana.

Manley Miles, professor of agriculture, started the plots. They were continued by George Morrow, the first dean of agriculture, and are named in his honor. The plots were originally established to determine the effect of different cropping systems on yield and soil properties.

Lessons from 1876 to 1903

The original experiment consisted of 10 plots, each ½ acre. The astronomy observatory was built on the two north plots in 1895. In 1903 the five south plots were discontinued and the three remaining plots were reduced in size.

The north plot was planted to corn every year, beginning in 1876. The middle plot was in a two-year rotation of corn-oats. Originally the south plot was in a six-year rotation of corn-corn-oats-meadow-meadow-meadow, but this was changed in 1901 to a three-year rotation of corn-oats-clover.

The highest yield obtained during this early period was 70 bushels per acre, produced on the six-year rotation plot in 1892. Two lessons were learned from the Morrow Plots during the first 28 years:

1. The highly fertile prairie soil could be depleted with cropping.

2. Depletion could be postponed by using crop rotations.

Lessons from 1904 to 1955

No soil treatment was applied to the plots until they were 29 years old. Beginning in 1904, manure, lime, and phosphorus (MLP) were added to the south half (subplot) of each plot. Also beginning in 1904, a catch crop was seeded on the south half of the plot in oats, and was plowed under the following spring for corn.

The first 100-bushel corn crop was grown in 1943 on the MLP subplot of the corn-oats-clover rotation. The highest corn yield during this era was 121 bushels per acre, produced on this same subplot in 1946.

From 1904 through 1955, corn was grown on all plots in nine different years. The data shown in Figure 1 are averages for these nine years. The following lessons were learned during this period:

3. The use of manure, limestone, and phosphorus increased crop yields. But fertilization did not completely replace the effect of rotation. The two- and three-year rotations with MLP produced higher corn yields than did continuous corn with MLP.

4. Rotation did not completely replace the effect of fertilization. The highest yields were obtained with MLP on the rotation plots.

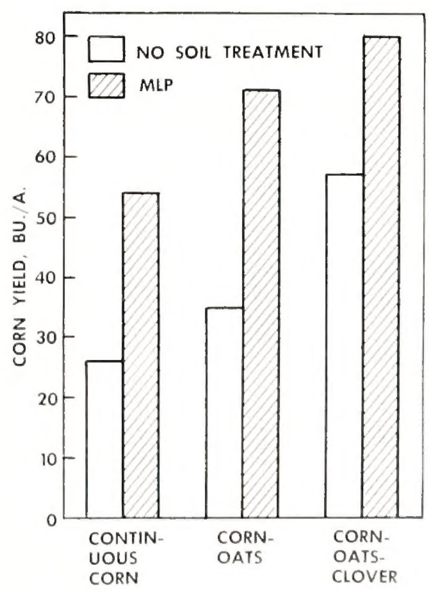
Lessons from 1955 to 1975

In 1955, when the plots were 80 years old, they were further subdivided. Medium levels of limestone, nitrogen, phosphorus, and potassium (LNPK) were added to part of each previously untreated subplot and each MLP subplot.

In 1967 two more changes were made: High levels of LNPK were added to certain subplots, and it was decided to substitute soybeans for oats in the two-year rotation.

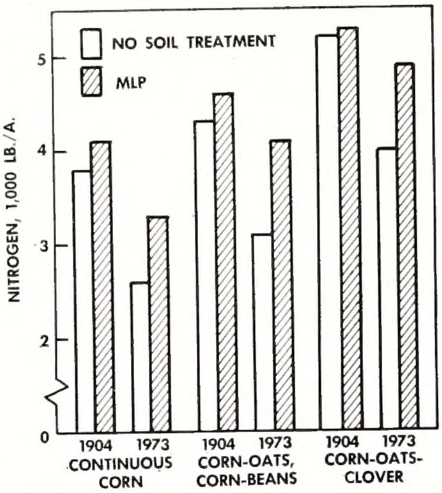
Yields from the subplots receiving a medium level of LNPK since 1955 indicate that mistakes can be at least partly corrected. On the plot that had been growing continuous corn without any soil treatment for 79 years, yields increased by 50 bushels per acre the very first year that LNPK was added. As an average from 1955 to 1973, this plot yielded 91 percent as much as the continuous-corn plot that had received MLP since 1904 and LNPK since 1955 (Table 1). If only recent years (1967-1973) are considered, the plot untreated before 1955 yielded 97 percent as much as the MLP-plus-LNPK plot.

On rotation corn, the medium level of LNPK erased the differences between previously treated and untreated plots. With the three-year rotation, yields since 1955 have averaged 135 bushels on plots that received no treatment before 1955, as compared with 134 bushels for plots receiving MLP since 1904, then LNPK. The higher yields from the



Effect of soil treatment and crop rotation on corn yields, 1904-1955. (Fig. 1)

L. F. Welch is professor of soil fertility; S. W. Melsted, professor of soil chemistry; and M. G. Oldham, agronomist.



Nitrogen content of soil as affected by crop rotation and soil treatment. (Fig. 2)

rotation corn than from the continuous corn, both with and without soil treatment, are probably due primarily to nitrogen symbiotically fixed by clover.

No doubt corn grown in rotation with a legume receives more nitrogen than corn grown continuously with no fertilizer nitrogen. But if nitrogen or other fertilizer nutrients are the only cause of yield differences between rotations, then these differences would be expected to disappear if more than adequate fertilizer is applied. However, even with the high level of LNPK begun in 1967, continuous corn has yielded 23 bushels per acre less than corn in a corn-soybean rotation (Table 2).

The highest yield ever recorded on the Morrow Plots was 191 bushels per acre, produced in 1975 on the high fertility plot in the corn-soybean rotation. The continuous-corn plot with high fertility yielded only 161 bushels in 1975. The reason for this difference in corn yield will have to wait for some future lesson.

In the corn-soybeans system, corn responded to soil treatment more than soybeans (Table 3). This is probably due to the fact that nitrogen fertilizer generally increases the yield of corn but not soybeans. Nitrogen from the air that is not available to corn becomes available to soybeans through the soybean-bacteria association.

These lessons were learned from 1955 to 1975:

5. If the topsoil remains, fertilizer can quickly restore productivity to unproductive soil. Plots that first received soil treatment in 1955 yielded 91 percent as much during 1955-1975 as plots that began receiving MLP in 1904 and LNPK in 1955.

6. Even with high fertility, yields of continuous corn have been only 87 percent as great as those of corn following soybeans.

7. The relative yield of soybeans is affected less by soil treatment than is corn yield.

Soil properties

The amount of nitrogen in the soil depends on both cropping practice and soil treatment (Fig. 2) and partly explains the differences in corn yields on the various plots. Considerable difference in nitrogen content due to crop rotation occurred by 1904, with the continuous corn plot being lowest in nitrogen. From 1904 to 1973, the nitrogen content of untreated plots has decreased 1,200 pounds per acre with all rotations. The loss has been less on plots receiving treatment since 1904.

With continuous corn and no soil treatment, soil nitrogen was only 68 percent as great in 1973 as in 1904. On the corn-oats-clover plot receiving MLP since 1904, there was 92 percent as much nitrogen in 1973 as in 1904. Organic matter content closely follows nitrogen content, except that organic matter is about 20 times greater than nitrogen.

Poor yields on the untreated plots reflect not only low nitrogen, but also low pH, phosphorus, and potassium levels, as shown by the following figures:

	pH	P_1, *lb./A.*	*K, lb./A.*
Untreated plots	5.4	12	200
Desired levels	6.4	45	300

On the untreated, continuous-corn plots, the harvested grain has removed about 2,130 pounds of nitrogen per acre, 525 pounds of phosphorus, and 635 pounds of potassium since the plots began.

Table 1. — Corn Yields as Affected by Cropping System and Soil Treatment, 1955-1973

Soil treatment	Corn yields, bu./A.[a] Continuous corn	Corn-oats, Corn-soybeans[b]	Corn-oats-clover
None	42	58	76
MLP since 1904	90	124	136
Med. LNPK since 1955	113	126	135
MLP since 1904, med. LNPK since 1955	124	130	134

[a] All plots are planted to corn once every 6 years. Yields are the average for 1955, 1961, 1967, 1973.
[b] Corn-oats 1876-1967; corn-soybeans since 1968.

Table 2. — Corn Yields With Continuous Corn and Corn-Soybeans, 1969-1975

Soil treatment	Corn yields, bu./A.[a] Continuous corn	Corn-soybeans[b]
None	50	80
MLP since 1904	94	131
Med. LNPK since 1955	134	149
MLP since 1904, med. LNPK since 1955	139	147
MLP since 1904, high LNPK since 1967	148	171

[a] Yields are the average for 1969, 1971, 1973, 1975.
[b] Corn-oats 1876-1967; corn-soybeans since 1968.

Table 3. — Corn and Soybean Yields With Different Soil Treatments in the Corn-Soybean System[a]

Soil treatment	Corn Bu./A.	Corn Pct.[b]	Soybeans Bu./A.	Soybeans Pct.[b]
None	80	47	38	76
MLP since 1904	131	77	52	104
Med. LNPK since 1955	149	87	49	98
MLP since 1904, med. LNPK since 1955	147	86	51	102
MLP since 1904, high LNPK since 1967	171	100	50	100

[a] Soybean yields are the average for 1968, 1970, 1972, 1974; corn yields are the average for 1969, 1971, 1973, 1975.
[b] Yield as a percent of yield with high LNPK treatment since 1967.

A historic landmark

The Morrow Plots have been a National Historic Landmark since 1968. The designation was made by the U.S. Department of the Interior because of their exceptional value — a value that still continues.

Do Machine Sheds Pay?

DONNELL HUNT

DOES a storage building for farm implements repay its cost in some way? Although this question often comes up, it has never been answered unequivocally.

Housing farm field equipment has several potential benefits. Economically, it may retard depreciation or reduce repair and maintenance costs. Esthetically, storing machines in buildings keeps the farmstead uncluttered and attractive. Operationally, a machine storage building permits repair and maintenance work to proceed efficiently in any weather.

An opportunity to study some of the economic benefits of machine housing arose during a general study of field machine repair costs on 39 farms. Information was obtained on the type of machine storage used by the farm operators. Repair and maintenance costs were then compared for implements stored in different ways. The operational, esthetic, and reduced-depreciation benefits of housing were not determined as they depend on subjective evaluations.

Farm characteristics

The 39 farms in the study were typical of east-central Illinois. Most were cash grain farms, with 531 average annual acres processed by the surveyed equipment. The typical cropping program consisted of about equal acreages of corn and soybeans with some land in wheat and hay.

Most of these farms had excellent machinery storage facilities: Three types of storage were reported: outdoor, under-roof, and enclosed. Two uses, storage and repair, were reported for the buildings. All the farms had some type of machinery shelter. Over 89 percent of the farmers had some enclosed storage space, and 41 percent stored all their equipment in enclosed buildings. More than 87 percent had enclosed repair space, and more than 43 percent had heated repair space.

The type of storage varied with the type of machine (Table 1). Tillage implements were left outside more than other machinery. These implements are often too wide to go through existing doorways, and they have few moving parts that will bind with rust. The fact that tractors, harvesters, and seeders have more moving parts may contribute to their being stored indoors.

An average of 3.18 machine storage buildings was reported per farm. Undoubtedly, some buildings primarily used for crop storage and animal housing did secondary duty as machine storage. Such a large number of buildings per farm may also reflect the use of old buildings remote from the farmstead and the continued use of older machine sheds even after a newer facility has been built.

Costs for four implements

Only the data for plows, disk harrows, and cultivators gave any promise for showing the effects of type of storage on repair and maintenance costs (R and M). These costs were computed and related to the storage type. Data were gathered between 1965 and 1973. All cost data were corrected to 1972 values using a 4-percent inflation rate compounded annually. The data for a machine used 1 year are counted as 1 machine-year.

Table 1. — Type of Machine Storage on 39 Farms

Machine	Pct. stored		
	Enclosed building	Under roof	Out-doors
Tractors	80.5	17.0	2.5
Combines	85.3	14.7	0
Corn planters	79.0	21.0	0
Plows	64.7	29.4	5.9
Disk harrows	50.0	30.0	20.0
Row cultivators	84.6	7.7	7.7
Field cultivators	53.8	30.8	15.4

Table 2. — Average R and M Cost for Each Type of Machine Storage

	Enclosed building	Under roof	Out-doors
Moldboard plows			
Average, $/A.	.34	.27	.11
Std. deviation	.58	.30	.02
Machine-years	75	45	2
Disk harrows			
Average, $/A.	.05	.04	.07
Std. deviation	.07	.02	.09
Machine-years	13	15	12
Row cultivators			
Average, $/A.	.06	.10	.07
Std. deviation	.04	.02	.01
Machine-years	50	6	4
Field cultivators			
Average, $/A.	.08	.08	.07
Std. deviation	.07	.06	.04
Machine-years	36	12	9

Annual R and M costs are expected to vary with the size of machine and its annual use. To remove the variability due to these two factors, costs per acre were calculated; that is, annual R and M costs were divided by the annual acreage of use. However, this did not remove all variability. A standard deviation as great as or greater than the mean was obtained for the plows and disks (Table 2).

Results inconclusive

Contrary to expectation, enclosed storage did not significantly reduce R and M costs for any of the four implements. In fact, moldboard plows stored in an enclosed shelter had higher costs than those stored outside or in an open shelter. An analysis of variance revealed no significant difference among the means.

In summary, these data indicate that enclosed shelters for machinery cannot be justified on the basis of reduced R and M costs. To justify machinery housing, one must give substantial value to esthetics, to having enclosed space for working on the machines, and to increased resale value of the machinery.

Donnell Hunt is professor of agricultural engineering.

Development of Rural Illinois Communities

JAMES WILLIAMS, BRENDA ROOT, and ANDREW J. SOFRANKO

Over the past few decades there have been periodic revivals of concern for improving rural communities and the lives of their inhabitants. Still, many small communities continue to experience formidable development problems and to experiment with a wide range of programs and improvement strategies.

One of the most common means for improving rural communities has been economic development — particularly expansion of the town's economic base and creation of new employment opportunities. The main options for expanding and diversifying a community's economic base are recreational, commercial, or industrial development. The one most frequently chosen has probably been industrial development — largely because it is presumed to provide the most new jobs and produce the most revenue.

Rural communities have invested much time and money trying to attract new firms. Various approaches have been tried: For example, economic plans or reports have been drawn up; various civic groups have been mobilized; community services such as water- and sewage-treatment facilities have been improved; zoning laws have been changed; industrial sites have been created; and tax breaks, low rents on municipally owned buildings, low-interest financing, and other economic incentives have been made available.

But a large number of communities are pursuing a relatively small number of firms, and factors beyond the control of a community help to determine a firm's choice of a new site. Such factors include geographic location, existing economic diversity of the community, nearness to metropolitan and larger urban centers, and access to transportation, raw materials, and labor.

To what extent can a community's efforts counteract the effects of a poor geographic location or other disadvantages beyond its control? So far little systematic research has been done on this question, or on the whole problem of community development. We know very little about the relative success of rural communities in creating new jobs or of the factors underlying success and failure. Community and regional development agencies responsible for attracting new industry have little research information with which to work, and often what they do have is for other sections of the country, is based on small samples, or focuses on "success" stories.

Questions explored

Research now under way in the Department of Agricultural Economics is designed to answer several questions: (1) How many small Illinois communities have actually acquired new firms and jobs in the past 10 years? (2) How large, in terms of employees, and thus how significant, are these new firms? (3) What types of firms are rural communities in Illinois able to acquire? (4) What do knowledgeable community leaders perceive to be the important reasons for success in attracting new firms? (5) How do "successful" and "unsuccessful" rural communities compare in terms of several factors believed to be important in determining the location of new firms?

To help answer these questions, a survey was undertaken in 1974 of 106 Illinois towns with populations between 1,000 and 2,500 according to the 1970 Census. The towns, representing every area of the state, included 43 percent of all communities in that size range.

Table 1. — Type of New Firm With the Largest Payroll

Type of firm	No.	Pct.
Manufacturing	37	64.9
Wholesale trade	6	10.5
Construction	5	8.8
Mining	3	5.2
Transportation and utilities	2	3.5
State and local government	2	3.5
Service industries	1	1.8
Agricultural	1	1.8
Total	57	100.0
Type unknown	3	

Questionnaires were administered by telephone to leaders in each sample community. They were selected either because they had been involved in local development and planning activities, or because they were thought to be knowledgeable about the economic activity of their communities. Chamber of Commerce officials made up 14 percent of the group; municipal government officials, 31 percent; local businessmen, 18 percent; bankers, 23 percent; officials of planning and industrial development commissions, 8 percent; and other community leaders, 6 percent.

Amount of business attracted

As a basis for measuring success in attracting employment, we asked whether any new firms employing at least 10 persons had been established in or near the community in the past decade. The use of 10 new jobs as a cutoff point is somewhat arbitrary, but it should help us get a rough idea of the progress that rural communities have made in economic development.

Only 54 percent of the communities had attracted a firm of this size, although most had tried to do so. If we adopt a more stringent criterion for success — 50 new jobs — then only 28 percent of the communities could be termed successful.

James Williams is a graduate research assistant; Brenda Root, a former graduate student; and Andrew J. Sofranko, associate professor of rural sociology.

Table 2. — Perceptions of Community Leaders as to Factors Influencing Location of New Firms

Type of community attribute	1st reason cited No.	1st reason cited Pct.	2nd reason cited No.	2nd reason cited Pct.
"Variable"	24	40.1	23	45.1
"Fixed"	28	46.6	23	45.1
Unknown	8	13.3	5	9.8
Total	60	100.0	51	100.0

Table 3. — Comparison of Some Variable and Fixed Community Attributes in Communities That Have and Have not Acquired New Firms

Type of community attribute	Communities without new firms	Communities with new firms	T-test[a]
Variable attributes			
Pct. of communities having an economic plan or report	33.3 (60)[b]	61.0 (82)[b]	−3.38*
Pct. having development sites available	70.6 (68)	92.6 (94)	−3.54*
Av. no. of community groups represented in development planning activities	2.6 (66)	3.6 (94)	−3.91*
Fixed attributes			
Av. population, 1970	2,055 (68)	2,408 (94)	−2.10*
Av. population change, 1960-1970, pct.	34.8 (67)	48.1 (93)	− .70
(*Median*)	(*11.6*)	(*12.0*)	
Pct. located in an SMSA county	35.3 (68)	50.0 (94)	−1.88*
Av. miles to nearest SMSA city	31.6 (68)	28.5 (94)	.87
Av. miles to an interstate interchange	18.0 (67)	13.2 (94)	1.56
Av. no. of accesses to U.S. highways	.6 (68)	1.0 (94)	−2.13*

[a] The T-test determines whether or not the differences between means are due to random chance. The larger the T-value the greater the probability that a difference is not due to chance. A negative sign in this column indicates that communities without new firms show lower values than those with new firms. (In these tests, degrees of freedom ranged from 99 to 159.)
[b] Numbers in parentheses in this column indicate the number of respondents answering the question.
* Statistically significant at the 5-percent level, on the basis of one-tailed test.

We did not compile data for every new business acquired. However, in communities reporting new firms with more than 10 new jobs, we did ask for the type of new business with the largest payroll. In 65 percent of these communities, manufacturing, particularly light manufacturing, was most important; in 11 percent, wholesale establishments (Table 1). Service industries accounted for a surprisingly small proportion (2 percent) of the largest new industries.

Reasons for success

As already mentioned, some factors influencing a community's development are beyond its control, at least in the short run. These we term "fixed," in contrast with the "variable" attributes which a community can control.

When asked to evaluate the various factors that may help attract new business to a community, the respondents were inclined to give more weight to fixed attributes than to variable ones (Table 2). This response indicates a less than optimistic outlook for the economic development of small Illinois towns. However, a brighter picture emerges when we compare the actual attributes of towns that have and have not attracted businesses employing 10 or more people within the past decade.

Three variable attributes were selected for comparison: (1) the presence or absence of a community economic plan or report, (2) availability of building sites, and (3) the representation of community groups in development planning activities.

Among the relatively fixed attributes compared were the size of community and percent population change between 1960 and 1970. These were chosen because it has been argued that, even among rural communities, the largest and fastest growing ones are most likely to be favored by new firms.

Two other fixed attributes were location of the community inside or outside a standard metropolitan statistical area (SMSA), and distance from the central city of an SMSA. Also, accessibility of transportation was measured in terms of distance to an interstate exchange, and access to the community via U.S. highways (each entry or exit was counted as one access).

Results demonstrated clear differences between towns that had acquired new firms and those that had not (Table 3). The more successful towns are more likely to have economic reports. They are almost certain to have sites available for development. And they have a greater number and diversity of groups involved in planning local development. Moreover, these communities, on the average, are larger, faster growing, and more likely to be located in an SMSA county and close to urban centers. They are closer to interstate highways and have more access to U.S. highways. The differences between the two sets of communities were statistically significant for all of the variable attributes and for three fixed attributes — location in an SMSA county, size, and access to U.S. highways.

Some hope justified

The data confirm that not all rural communities are similarly endowed and that the differences affect their ability to attract new firms. But the so-called variable attributes turn out to be much more closely related to firm location than are the more fixed attributes of location, size, and transportation. The findings thus provide some support for those engaged in community development efforts.

Unfortunately, we have no way of knowing to what extent planning groups, availability of economic reports and sites, and SMSA county location are directly responsible for attracting new business or are merely associated with some other factor which truly affects local development success. Additional analyses can be undertaken and different measures constructed. For the present, however, the data suggest that the location of new employment opportunities is not entirely predetermined for rural communities. What they do to organize and plan their development may have at least as much bearing on their success as their location, size, growth, or access to transportation.

Birds before, during, and after molting. (Fig. 1)

Forced Molting: One Way To Lower Production Costs

D. J. BRAY, S. F. RIDLEN, and H. S. JOHNSON

PULLET depreciation is one of the major costs of producing eggs. This depreciation includes both mortality and the decrease in value of layers between the onset of egg production and the end of the laying period.

Currently, it costs an egg producer about \$2.25 to either produce or buy ready-to-lay pullets 20 weeks of age. After 12 months of egg production, the average salvage value per bird housed is about 25 cents, leaving a net cost of \$2.00. An allowance of ½ to 1 percent mortality per month is included in this calculation. If the net cost of \$2.00 is distributed over an anticipated production of 20 dozen eggs, the depreciation cost amounts to 10 cents per dozen.

Since no further depreciation other than mortality occurs when layers are kept for more than the usual 12 months of egg production, poultrymen have raised the question of just how long layers should be kept. They reason that, by keeping hens longer, they can distribute the depreciation over a greater number of eggs, thus reducing the cost per dozen. Further questions then arise of how to deal with such problems as the lower rate of lay of older hens and the poorer quality of their eggs.

As poultrymen have known for years, egg quality and rate of lay are both improved when a hen returns to production after molting her feathers. But modern strains of layers kept in environmentally controlled houses will continue to lay poor-quality eggs at a low rate well beyond 12 months unless the birds are forced to molt.

Numerous questions have arisen in recent years concerning the biological and economic feasibility of "force-molting" layers. How should molting be induced? How long should the birds be held out of production? How often should layers be force-molted? Are the management stresses used to initiate a molt likely to increase mortality?

In response to these questions and others from egg producers, we have conducted several trials with forced molting in recent years.

How study was conducted

One 2-year study involved 240 White Leghorn pullets. At 23 weeks of age, the pullets were divided into two equal groups and placed in individual cages in two environmentally controlled rooms. In one room the birds were force-molted (FM) twice. Their production was compared with that of the non-force-molted (NM) birds in the other room.

All birds were started with 16½ hours of light. This amount was increased 15 minutes a week until the birds were receiving 18 hours of light by the seventh week. Thereafter, the amount of light remained constant except for two 4-week periods, one starting after 36 weeks of lay, and the other after 70 weeks. During these periods, the FM pullets received only 8 hours of light daily.

The FM birds were fasted for the first 10 days of each 4-week period of reduced light. They were then fed a 96:4 mixture of cracked corn and oyster shells. The rest of the time, the FM birds, like the NM birds, were given free access to a 17-percent protein cage layer diet. Water was available to both groups at all times.

Egg production and quality

Production patterns of the two groups were similar through 36 weeks of lay. Both groups peaked at 85 percent production during the sixth week, then began a fairly steady decline at the twelfth week.

In the NM group this decline continued until the seventy-second week of lay, after which production stabilized in the 20- to 30-percent range. All pullets in this group ceased to lay and molted at some time during the experiment.

In the FM group egg production dropped to zero within 4 days after feed was withdrawn and light was reduced at the end of 36 weeks of lay (Fig. 2). A similar decline in production occurred during the second molting period. Eight weeks after the first molt was induced, FM pullets began producing 20 to 25 percent more eggs than the NM group. This difference continued until the end of the experiment except during the second molt. Rate of lay of the FM group peaked at progressively lower levels in the first, second, and third laying cycles.

D. J. Bray is professor of animal science; S. F. Ridlen and H. S. Johnson are professors of poultry extension, Department of Animal Science.

Average rate of lay during the 2 years was 54.9 percent for the FM hens; 45.6 percent for the NM group. The difference amounted to 66 eggs per bird in favor of the FM hens. The two 8-week periods during which they laid practically no eggs was apparently more than offset by the NM birds' prolonged periods of molt and low production.

Quality measurements were made on a random sample of 60 eggs from each group during the weeks indicated in Table 1. The measurements at 36 and 70 weeks were made just before the forced molts; those at 49 and 82 weeks were made shortly after the FM group's return to heavy production (Fig. 2).

Forced molting did not affect the normal pattern of egg size (Table 1). It did increase firmness of the egg white, as indicated by Haugh unit values, but this improvement was short-lived. Shell thickness, which is a reliable index of the egg's ability to withstand breakage and quality deterioration, was also consistently improved by forced molting. Again, however, the improvement did not last long, as evidenced by the similarity of shell thickness in both groups during the last week of the assay.

Table 1. — Egg Quality and Body Weight of Non-molted (NM) and Force-molted (FM) Layers

Weeks of lay	Egg weight, oz doz.		Haugh units		Shell thickness, .001 in.		Body weight, gm.	
	NM	FM	NM	FM	NM	FM	NM	FM
13	23.5	23.2	77.2	77.1	15.3	15.0		
27	25.0	24.5	74.0	72.6	14.6	14.6		
36	25.3	26.1	72.0	73.6	14.7	14.5	1,953	1,921
49	25.4	26.0	71.2	77.5	14.1	15.2		
70[1]	25.8	25.5	67.8	73.9	14.5	14.6	1,976	1,940
82	27.2	27.0	76.1	80.1	13.8	14.9		
94	26.2	25.8	73.0	75.9	13.8	14.0		
104	27.6	26.5	66.8	69.9	14.1	14.0	2,109	2,153

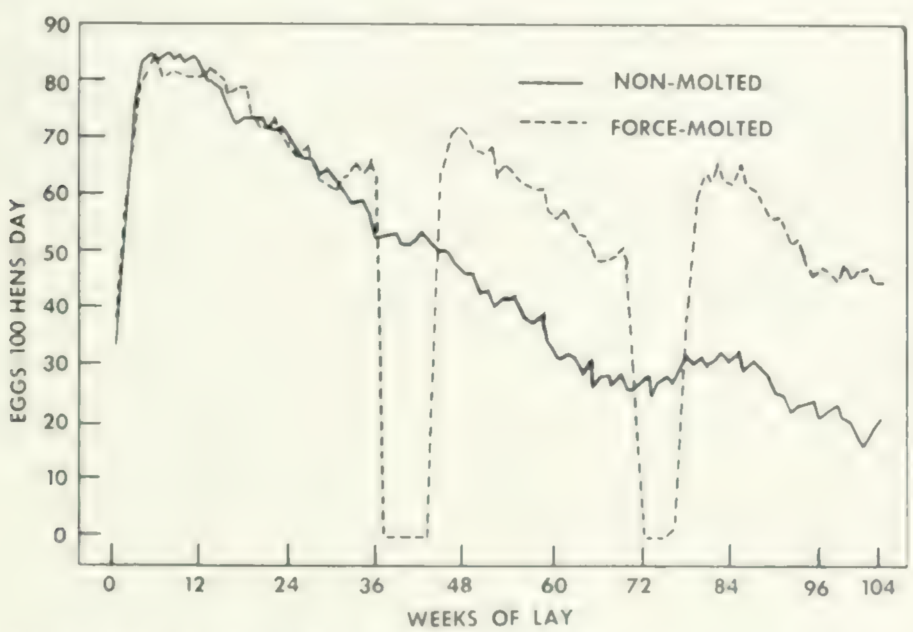
[1] FM hens started molting at end of thirty-sixth and seventieth week of production.

Mortality

Mortality was similar for the two groups. In the NM group 23 birds, or 19.2 percent, died; in the FM group, 20 or 16.7 percent. In both groups, one-third of the deaths occurred during the first 52 weeks. Mortality during the forced-molting periods was no greater than normal despite the rigorous treatments used. No culling was done during the experiment.

Body weights

There was no evidence that forced molting caused an appreciable change in body weight by the end of the test (Table 1). However, the FM birds did temporarily lose 438 grams during the first 10-day molting period and 425 grams during the second period. Each loss amounted to 23 percent of the body weight. By the time the birds returned to production, their weight was back to normal.



Rates of lay during a 2-year period for pullets that were and were not force-molted after 36 and 70 weeks of lay. Fig. 2

Producer decisions

Our data clearly demonstrate that, if layers are kept for a prolonged period, it is better to force-molt them than to let them molt at will. The more rapid and complete molt induced by forced molting apparently increases the average rate of lay and markedly improves egg quality.

Whether pullets should be molted and kept for more than one period of egg production is another matter. Factors such as the cost and availability of new pullets and the current value of spent or old hens must be considered. The degree of price discrimination against lower quality eggs is another important consideration, as is egg breakage.

As long as a wide margin exists between the cost of producing pullets and the market value of spent hens, forced molting followed by another production cycle remains a viable alternative for egg producers. The feasibility of the practice varies from year to year, even month to month, depending on the short-term economic outlook and the availability of replacement pullets on short notice. In the long run, the answers will depend on the outcome of further experiments designed to minimize the time and cost of forced molting while maintaining the benefits.

In the final analysis, well-informed poultrymen will adopt those practices that maximize the efficiency with which they can use increasingly limited and expensive feedstuffs to produce eggs — one of nature's most complete prepackaged foods.

Performance Of Systems Controlling Runoff From Feedlots

E. C. DICKEY and D. H. VANDERHOLM

Illinois has about 15,000 beef feedlots, 40,000 hog farms, and 10,000 dairy farms, as well as poultry and sheep enterprises. These livestock operations are of tremendous economic importance. They may also at times be a source of water and air pollution.

Under present U.S. Environmental Protection Agency (EPA) regulations, runoff control is mandatory for large feedlot operations. Now the EPA and the Illinois Pollution Control Board have proposed livestock waste regulations that will apply to all livestock operations regardless of size.

These regulations will require modification of many facilities. The major problem in Illinois will be for small and medium-sized operations to economically control polluted runoff from feedlot areas. Where problems exist, treatment and release is not usually a practical solution.

Runoff control systems have been developed from experience and research both in Illinois and in other states. The basic system consists of a runoff collection component such as a channel, a settling basin to settle out a portion of the manure solids, and a holding pond to store the liquid after settling.

Liquid from the holding pond is normally spread on nearby cropland. It has value as a supplemental water supply and as a source of nutrients. However, it contains only a very small part of the nutrients in manure. Most of them are retained with manure solids on the lot surface and in the settling basin.

So far relatively few runoff control systems have been installed in Illinois, and most of these are fairly new. Because experience with such systems is limited, some objective evaluation seemed desirable.

Since the spring of 1974, we have been monitoring several beef, dairy, and swine operations with runoff control systems. The farms are in central and northern Illinois.

We have four major objectives: (1) To determine whether the installations are preventing air, water, and soil pollution; (2) to discover any management problems that could be eliminated by modifying the system; (3) to determine the adequacy of present design criteria for the system's components — for example, the size and shape of the settling basin; (4) to study the balance of nutrients, particularly nitrogen, through the runoff control systems.

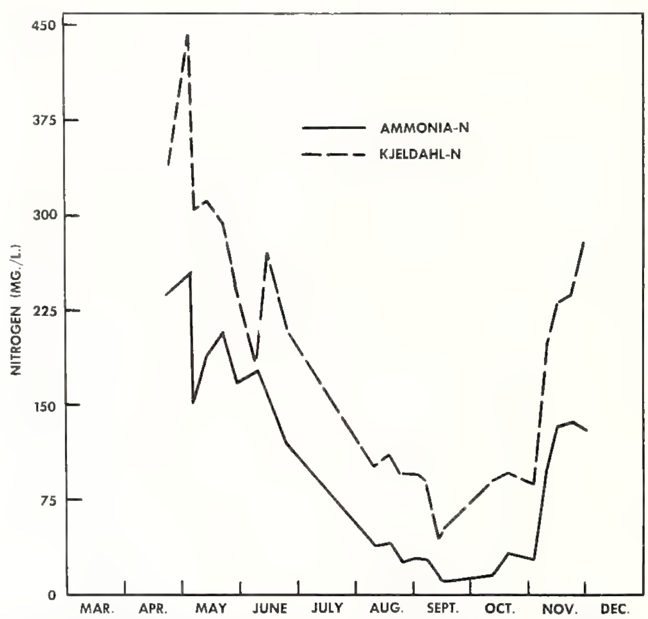
System A studied in detail

One central Illinois system (referred to as System A), is being monitored especially closely. Installed in 1972, it controls the runoff from a beef feedlot having a capacity of about 1,125 head in both open lot and confinement facilities.

The basic system consists of a settling basin, holding pond, irrigation pump, piping, and sprinkler. Holding-pond liquid is irrigated onto adjacent land used for corn production. Solids from the feedlot surfaces, settling basin, and holding-pond bottom are also applied to cropland.

General performance of the system to date has been excellent. It has contained runoff long enough that spreading effluent during bad weather has not been necessary. No accidental overflow has occurred or even threatened.

In 1974 excellent corn yields were obtained on 20 acres that had received no fertilizer other than the holding-pond liquid. Size of application was based on nutrient analysis of the effluent. For various reasons, the



Seasonal variations in ammonia-N and Kjeldahl-N in holding pond of system A. (Fig. 1)

E. C. Dickey is a research assistant and D. H. Vanderholm is assistant professor of agricultural engineering. This research was supported in part by a grant from the Illinois Institute for Environmental Quality.

effluent nutrient content varies widely during the year. The waste therefore has to be analyzed periodically to determine the actual amount of nutrient being applied.

Variations in nitrogen

Seasonal variations in ammonia-nitrogen and Kjeldahl-nitrogen in System A are shown in Figure 1. Kjeldahl-nitrogen includes organic nitrogen and ammonia. For anaerobic holding ponds such as those being studied, nitrate and nitrite forms of nitrogen are quite low. Kjeldahl-nitrogen therefore is a good indicator of total nitrogen.

Both ammonia-nitrogen and Kjeldahl-nitrogen are at peak concentrations in the spring. As water temperatures begin to rise, nitrogen concentrations start a decline that continues into late summer. This decreasing trend is largely due to volatilization of ammonia from the pond surface.

By late fall, nitrogen concentrations are once again high, mainly because of the increased number of rainfall-runoff events. Also, as the water becomes cooler, microbial activity declines, and less of the nitrogen entering the pond is assimilated or decomposed.

If a farmer were to irrigate with liquid from this pond in mid-April, he would apply 85 pounds of nitrogen with each inch of water. If he irrigated near the end of June, he would apply only 35 pounds of nitrogen.

Besides the seasonal variations in the nitrogen content of holding ponds, there are large variations among systems (Table 1). Differences between the beef, dairy, and swine operations can largely be explained by the differences between the animals and their rations.

Variations among the beef facilities result from lot management and the concentration of animals. Lot management refers to the amount of manure which is allowed to build up on the lot surface before cleaning. Weekly scraping of the lots would contribute smaller amounts of nutrients to the holding pond than would monthly scraping. With a given level of lot management, the amounts of nutrients entering the holding pond would increase with the number of animals.

Table 1. — Average Concentrations of Nitrogen, Phosphorus, and Potassium in Holding Ponds of Six Operations

Type of operation	Total Kjeldahl-N, ppm	Ammonia-N ppm	Ammonia-N % of av. total N	P, ppm	K, ppm
Beef[a]	333	125	44	84	311
Beef	90	45	50	32	235
Beef	22	7	29	7	82
Beef and swine	350	269	85	50	161
Swine	771	563	74	106	678
Dairy	121	54	41	40	236

[a] This was "system A." It was sampled weekly, while the others were sampled monthly.

Table 1 includes the percentage of the total nitrogen which is in ammonia form. A high percentage of ammonia has both advantages and disadvantages. Ammonia becomes available to crops almost immediately, while nitrogen in an organic form needs more decomposition before becoming available. However, ammonia-nitrogen can be lost through volatilization to the atmosphere, especially if the pH is greater than 7 and the holding pond water is being applied to the crop through a spray nozzle.

Phosphorus and potassium

As shown in Table 1, the systems differ widely in phosphorus and potassium concentrations. The reasons are similar to those for the nitrogen variations.

Phosphorus and potassium do not exhibit strong seasonal variations. The potassium concentrations in the holding pond water increase slightly during the summer, probably as a result of evaporation. The phosphorus concentration, on the other hand, slightly decreases through the summer. This decrease is probably due to the precipitation of insoluble phosphorus compounds. Sediment from the holding ponds was found to contain about 100 times as much phosphorus as the holding pond water.

Soil analysis

A number of soil tests were made on the cropland at System A to determine whether differences existed between the disposal area, which received either holding pond water or solid manure, and the area that received commercial fertilizer. Soil profiles were tested to a depth of 15 feet.

No significant differences between the areas were found when comparing potassium, phosphorus, or Kjeldahl-nitrogen. Nitrate-nitrogen concentrations did not significantly differ in the upper 5 feet, but at the 5- to 10-foot depth, they were significantly higher in the disposal area than in the commercially fertilized area. The concentration in the disposal area averaged 7.6 ppm (air dry basis) per foot of depth sampled; in the fertilized area, 1.7 ppm.

Air pollution

In general, the runoff control systems were designed to prevent water and soil pollution and not necessarily to control odors. However, no complaints about odors have been received on any of the farms studied. Some odors are present near the systems, but it is difficult to determine whether the odors are caused by the runoff system or whether they come from the lot area. Odor problems are minimized by good management, particularly periodic cleaning of the lot and settling basin.

Systems adequate

The feedlot runoff control systems under study are helping to prevent water and soil pollution. Design capacities for the holding pond and settling basin have been adequate. Both liquids and solids can provide soil nutrients. The quality of the holding pond water is largely determined by the size of the lot, number of animals, and management of the lot and runoff control systems.

Management was adequate in all the systems. It is the most important factor in preventing water pollution, providing the greatest nitrogen benefit on the disposal area, and reducing odor problems.

Women's Experience of Isolation After Moving to a New Community

JEAN PETERSON

MOBILITY has become a way of life for many urban Americans. In a recent book, Vance Packard estimates that "40 million Americans now lead feebly rooted lives."

As people move around the country, they can no longer depend on their extended families for daily support. So the members of the nuclear family may face loneliness in a new community. While family sociologists have repeatedly considered the structural isolation of American families, few scholars have questioned the effects of this isolation on the persons who experience it. A group of graduate students and I therefore conducted a pilot study to examine the effects of mobility and resultant isolation on women.

The sample

We conducted in-depth, hour-long interviews with 27 women selected because they had lived relatively few years in their present community and had probably had the experience of being highly mobile. All were in their twenties and thirties, all were married to professional men, and all but one had children. The women had completed an average of 16.5 years of schooling. Twelve were employed outside the home.

Mean number of years married was 8.33, and mean number of homes occupied since marriage was 4.5. The women had lived in their present community an average of 2.11 years. Mean number of miles of the last move was 1,543, but for five of the women the last move was within their present community. Half of them lived in the same subdivision, which they generally considered "friendly."

Isolation and mobility

All but five of the women had experienced isolation at some time; several were experiencing it when we were conducting interviews. In its mildest form, isolation is experienced only as loneliness during the day when a woman is at home alone, or difficulty in finding friends in a particular community.

At the other extreme, responses include severe depression, serious family problems, and loss of confidence in social skills. One woman, describing her first experience with isolation said she "almost had a mental breakdown." Another developed erratic sleep patterns, and still another found that loneliness gave her a "distorted view of things."

A woman who sees no one but her husband and children said, "It's very depressing. You take it out on the kids and husband. I have a feeling that's why there are battered children." Another described symptoms of faintness, inability to structure time, loss of self-confidence even in familiar situations, and weight gain before she identified and mastered the source of her problem.

Ten women related isolation or loneliness specifically to the mobility of themselves and their friends. One woman, who said she can normally make friends easily and is "usually not lonely," observed that it took six months to a year to make friends in her present home and that she was lonely during that period.

Here are several other comments:

"I would like to know that my contacts are permanent. Nothing is permanent and that's very sad. . . . I'm looking for a permanent settlement where I can have the same friends for 30 or 40 years."

"I don't make friends any more because we are too mobile."

"I'm disillusioned with human relationships. In moving you just have to give up friends, so I don't look for close friends. People must learn to live with themselves, be happy, and see themselves as resources."

We did not specifically ask about extended family relationships, and only seven respondents volunteered information on this subject. While two respondents had extended family in the community, only one said she relied on these kinsmen. One woman expressed a desire to live near "family"; two wished their mothers could have been with them when their babies were born; and two call their families often, one to dispel loneliness, the other to confer on child-rearing problems.

Coping with isolation

Our respondents described several strategies for integrating themselves into a community, and routes for making contacts. We have categorized these into primary and secondary routes or strategies.

Primary contacts are those initiated by the woman herself — they include contacts made at work, with neighbors, or through organizations. Nine women considered work contacts to be the most important way of getting acquainted. Fourteen found neighbors an important source of support. Twelve of the women relied on a variety of organizations, such as

Jean Peterson is assistant professor of family relationships. Graduate students assisting in the study were Suzanne Anderson, Katherine Bullis, Catharine Cruttenden, Rita Curl, Mary Fritts, Fleda Jackson, Kathleen Kahn, Jamie Kearley, Claudia Larsen, Suzanne Larson, Barbara Leaf, Hollis Levan, Martha Power, Mary Ann Sissors, and Georgia Sorensen.

political and anti-pollution groups, women's clubs, P.T.A., and church, for their social contacts.

Secondary relationships are those which are initiated by the woman's child or husband and into which she is later drawn. Fifteen women indicated they became acquainted or friendly with parents of their children's friends. Twenty-three respondents said contacts made through their husband's work were important. Five women, who do not deliberately seek out social contacts, combat isolation simply by structuring their time alone; they "work hard at housework," sew, write, or play musical instruments.

Contacts made through the various strategies vary in quality. Twenty-six individuals said they have some friends in their present community, but only eight claim close friends there, and twelve specifically said they have no close or "really close" friends in the community.

The number indicating a lack of close friends is somewhat alarming in view of the characteristics our respondents ascribed to close friendship — mutual intimacy, trust, acceptance, and respect, and the freedom to ask for help. As they expressed it, they want "someone to talk to about personal matters"; "someone to help with a problem"; and "someone who can accept me for what I am."

Factors affecting isolation

While social isolation may generally be related to high mobility, other variables are involved as well. Two of these, the ages of children and the employment status of the woman, emerged clearly in our study.

Women reflected two contrasting attitudes toward the effect of children on social contacts. Ten women specifically mentioned children as inhibiting their social life, either now or in the past. One who said she used to make friends easily attributed her present isolation to the fact that she is "tied down with the kids" and can't get out to meet people. The "most isolating period" of another woman's life was the first winter after her baby was born. She said she didn't see anyone but her husband for six months.

Some mothers claimed that children helped them to meet people and make friends — either directly or indirectly through baby-sitting exchanges and volunteer work for schools. Nine mothers considered these activities significant social channels. One woman said that the only neighbors she knows are those whose children play with her children, but felt the relationships "mainly existed because of the children." Another woman noted that when her children are the same age as someone else's children in the neighborhood it's "easy to make friends."

The age of the children seemed to determine whether their mothers saw them as helps or hindrances in making social contacts. Young, dependent children require a large amount of their mothers' time at home, while older children meet people on their own. Although this is perhaps self-evident, the fact that it so clearly relates to mothers' perceptions of their experience is of interest.

The women's career or work status affected their experience of isolation and their strategies for coping with it. Generally speaking, the seven non-working, non-career-oriented women had developed more definite strategies for coping with isolation than had the employed women.

All the non-working women used structured organizations as means of meeting people and filling their time. Some explicitly saw this as a strategy for coping with mobility and isolation. One woman, who had moved several times, said that on arrival in her present community, she immediately joined seven organizations. Any time she is depressed, she has a choice of activities to get her out of the house. Several of these women described their present situation as "very satisfying," "ideal," or "good."

Among working women, those with part-time jobs and those who did not particularly want a career had developed more positive coping strategies than the career-oriented women. The career women tended to shun organized social activity.

One career woman said she didn't want to make community friends. She did express an interest in groups which might share her interests, but had not found any such groups.

Another working woman described structured social groups as "too plastic" and too "status-based." One unemployed career woman said that she generally tends to "shy away from contrived ways of grouping." Her sentiments were echoed by another unemployed career woman, who said she avoids "the tea-party life" and observed that "women who gather mornings for coffee are wasting their time."

Gainfully employed women were harshest in their judgments of women who suffer from isolation. Some comments were: "No one needs to be isolated"; "It's a state of mind"; "You must make an effort." Such variations in attitudes probably relate as much to personal history and personality as to present work status.

We had expected that women who had moved the oftenest might have acquired superior skills in adjusting to a new community and finding friends there. This was not borne out by our data. There was no apparent correspondence between the strategies adopted by women and the number of homes they had lived in.

Certainly factors other than mobility, work status, and ages of children affect isolation. Several women commented on the effect of seasonal change, finding winter the hardest time to settle into a new community. Some women have husbands with little or no time or inclination for social life, and others are themselves too busy for friends.

Conclusions

As the women in our study described isolation, it can be an excruciating experience. Considering its repetitiveness and duration, we might expect that, in some cases at least, isolation will seriously impair a woman's social skills, familial role, and self-image. Certainly we have suggested a fruitful line of inquiry and have identified an area sorely in need of attention.

Recycling Conserves Nitrogen In the Apple Tree

JOHN S. TITUS

NITROGEN is a precious commodity in the plant world. Because it is necessary for growth, plants have evolved complex means of getting the most use out of the nitrogen available to them.

Nitrogen utilization

In most annual crop plants, nitrogen is taken up by the roots, used first by the leaves, then translocated to the grain or seed late in the growing season. The nitrogen remaining in the unharvested plant parts returns to the soil in the autumn when the plants are plowed under or allowed to die in the field. This returned nitrogen then becomes available for use by succeeding crops.

In contrast, the apple tree, like many other woody perennial plants, will itself store nitrogen that is not used by the fruit. Only a small amount of nitrogen is returned to the soil when blossoms fall in the spring or leaves fall in autumn.

A mature apple tree can absorb as much as 3 pounds of nitrogen per year from the soil. Less than 1 pound will be in the fruit crop. The other 2 pounds are used for leaf, wood, bark, and root production. During a normal growing season, the leaves contain as much as 35 percent of the tree's total nitrogen. By late autumn this amount has been reduced to 15 percent.

The nitrogen lost from the leaves is translocated to overwintering storage sites in the woody tissues of the tree. Early in the spring, the stored nitrogen is mobilized for reuse in the development of leaf and flower buds.

In recycling nitrogen, the leaves of the apple tree undergo a series of biochemical changes quite different from what occurs in annual plants. During leaf growth in spring and early summer, nitrogen is used to make relatively immobile leaf proteins. This is done by polymerization of amino acids in the leaf tissues. During leaf senescence, a reverse process occurs. The proteins are broken down into their constituent amino acids, which move out of the leaves through the vascular system.

When the amino acids accumulate in the woody storage tissues, they are polymerized into storage proteins. Thus, the nitrogen is again immobilized in a tissue until it is needed in the spring. Nitrogen storage sites occur in bark, wood, and root tissues.

In early spring, the storage protein in the bark and wood dramatically decreases. Again the protein is broken down into amino acids, which the tree's vascular system carries up to the growing points for leaves and flower buds. To replenish amino acid-nitrogen, the tree's roots begin to remove inorganic nitrogen from the soil. The soil nitrogen is combined with organic acids to form more amino acids which are translocated up to the leaves. The cycle begins again.

Recycling studied

Research in our laboratory has centered on several steps of this dynamic recycling process. We are studying the nature of the storage proteins, the identity of the predominant amino acids, and the enzymes which break down protein into amino acids. In past years, we have investigated several biochemical changes related to nitrogen recycling in senescing leaves, and have examined the synthesis of amino acids in apple roots.

Response of Golden Delicious Apples to Nitrogen Treatments

Treatment[a]	Yield, bu. per tree	Pre-harvest drop, %	Fruit size, gm.	Maturity test, lb.
None	13.0	5.1	178	14.9
Soil	16.0*	6.2	180	14.8
5% urea	18.5*	5.4	185	14.7
10% urea	16.0*	6.2	181	14.8

[a] Urea applied to soil at the rate of 407 grams of N per tree in April; urea sprays of 5% (113 grams N per tree) and 10% (226 grams N per tree) applied to foliage in October.
* Significantly different from control at the 5% level.

One of our goals is to manage the nitrogen economy of apple trees more efficiently. Optimum nitrogen levels in apple orchards are not arrived at by simply measuring yields versus amount of nitrogen applied. Too much nitrogen delays maturity, reduces fruit quality, decreases fruit storage life, and may increase susceptibility of trees to winter injury. Thus, if we know how nitrogen is transformed in the tree, we can recommend nitrogen applications that will increase yield without diminishing fruit quality.

In one experiment, urea sprays were applied to leaves in the fall. The urea was quickly absorbed, then translocated out of the leaves. Along with the amino-acid nitrogen already present, the urea-nitrogen moved into storage sites in the tree. The rates of conversion of urea-nitrogen into ammonia, its synthesis into amino acids, and its accumulation into protein were determined. Several enzymes involved in these conversions were studied.

Fruit yields from the urea sprays were as good as or better than yields following ground applications of four times as much nitrogen (see table above). Fruit maturity, size, and preharvest drop were not affected by the treatments.

More extensive field trials of postharvest urea sprays are now being made. Considering the rising price of fertilizers, their economical use is important for apple growers.

John S. Titus is professor of pomology. Participating in the research were Brendon O'Kennedy, Patricia W. Spencer, and Walter E. Splittstoesser, Department of Horticulture; and Nail Ozerol and K. K. Shim, former graduate students.

Planting Depth for Asparagus

JOSEPH S. VANDEMARK, WALTER E. SPLITTSTOESSER, and JORGE W. GONZALES

THE DEPTH at which asparagus is planted varies with production areas. Asparagus crowns are usually planted 26 cm. deep in the sandy loam and peat soils of California. A planting depth of 13 cm. is common in most midwestern soils — 15 to 20 cm. in sandy areas.

An experiment to determine whether there would be any advantage to deeper planting in Illinois was initiated at Urbana in 1970. An earlier study in California had indicated that the number of spears from cultivar No. 72 decreases with planting depth, while average spear weight increases.

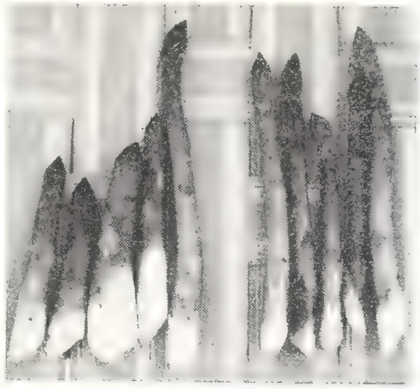
The Illinois experiment was conducted on Drummer silty clay loam. Crowns from seven asparagus cultivars were placed in furrows 13 cm. deep and covered with 3 cm. of soil in 1970. In 1971 they were covered with soil to a depth of either 13 or 26 cm. Plantings were made in two rows per bed, 30 cm. apart, at 7,100 crowns per hectare. Each cultivar at each planting depth was in a plot of 18.5 square meters, randomly distributed in the field. Plots were harvested for 6 weeks at irregular intervals in 1973, 1974, and 1975.

The shallower plantings came into production a week earlier each year than the deeper plantings. Although cultivars differed in yield, they all produced more spears, and a heavier total crop, when planted 13 cm. deep than when planted 26 cm. deep (Table 1). Some of the increased yield for the shallower plantings can be accounted for by the first two harvests. Since asparagus spear growth depends on soil temperature, these results are to be expected.

While spears were smaller in number from the deeper plantings, the individual spears were much larger and heavier (Tables 1 and 2). The percentage of spears in the smallest size category shown in Table 2 was considerably less for the deeper plantings than for the shallow plantings.

Some of these small spears are commercially unmarketable, although they may be acceptable to a home gardener. If these were not included in the total weight of spears, yields from the shallower plantings would become less attractive but they would still be higher than the yields from the deeper plantings.

Joseph S. Vandemark is professor of horticultural extension; Walter E. Splittstoesser, professor of plant physiology; and Jorge W. Gonzales, a former research assistant.



Spears from the planting 26 cm. deep (left) were much larger than those from the 13 cm. planting (right).

The following metric measurements are used in this article:

Centimeter (cm.) = 0.3937 inch

The planting 26 cm. deep was thus 10 inches; 13 cm., 5 inches.

Meter = 39.37 inches

Plots measuring 18.5 square meters were about 200 square feet.

Hectare (ha.) = 2.471 acres

Kilogram (kg.) = 2.2046 pounds

1 kilogram per hectare is equal to about 1 pound per acre.

Gram (gm.) = 0.0022 pound or 0.035 ounce

Table 1. — Influence of Planting Depth on Asparagus Yield

Cultivar	Planting depth, cm.	1,000 spears per ha.	Spear weight: Kg. per ha.	Spear weight: Each spear, gm.
No. 66	13	48	4,500	14
	26	30	3,300	18
Mary Washington	13	55	4,600	13
	26	19	1,900	20
Waltham	13	83	6,000	13
	26	23	1,400	15
Roberts	13	49	4,300	14
	26	17	1,900	19
Tetra	13	28	2,100	14
	26	23	1,500	19
Faribo (F_1 hybrid)	13	30	2,100	12
	26	14	1,200	15
No. 72	13	44	3,600	15
	26	28	2,500	21
Correlation coefficient		−0.72*	−0.68*	1.00*

* Correlation coefficients are significant at a 5-percent level of probability and indicate that deeper plantings produced fewer spears and less total weight, but more weight per individual spear.

Table 2. — Influence of Planting Depth on Diameter of Spears

Cultivar	Planting depth	Spear diameter, cm.[a] 0.6	0.9	1.2	2.0
	cm.	percent of spears			
No. 66	13	26	32	26	16
	26	17	27	30	26
Mary Washington	13	20	38	25	17
	26	7	22	28	43
Waltham	13	31	35	19	15
	26	9	36	24	31
Roberts	13	23	28	30	19
	26	12	25	29	34
Tetra	13	21	32	26	21
	26	16	25	22	37
Faribo (F_1 hybrid)	13	20	41	24	15
	26	12	26	27	35
No. 72	13	19	34	26	21
	26	10	26	27	37

[a] The indicated diameters represent the mid-points of the four size categories into which the spears were divided.

Although deeper plantings are recommended in some areas, our results show that planting deep does signicantly reduce the total weight of spears.

FARM BUSINESS TRENDS

NATIONALLY, gross farm income in 1975 will reach a new high. It will probably be about $1 billion more than the 1974 total of $101.1 billion. Yet production expenses have increased enough that net farm incomes will be slightly lower than last year. Realized U.S. net farm income will be about $25 billion, compared to $27.7 billion in 1974. Even so, this will be the third highest year for net U.S. farm income.

Incomes have been boosted by the production of record wheat and corn crops and by favorable prices, including a record high price for hogs and increased prices for other livestock. Strong domestic and foreign demand has made these favorable prices possible.

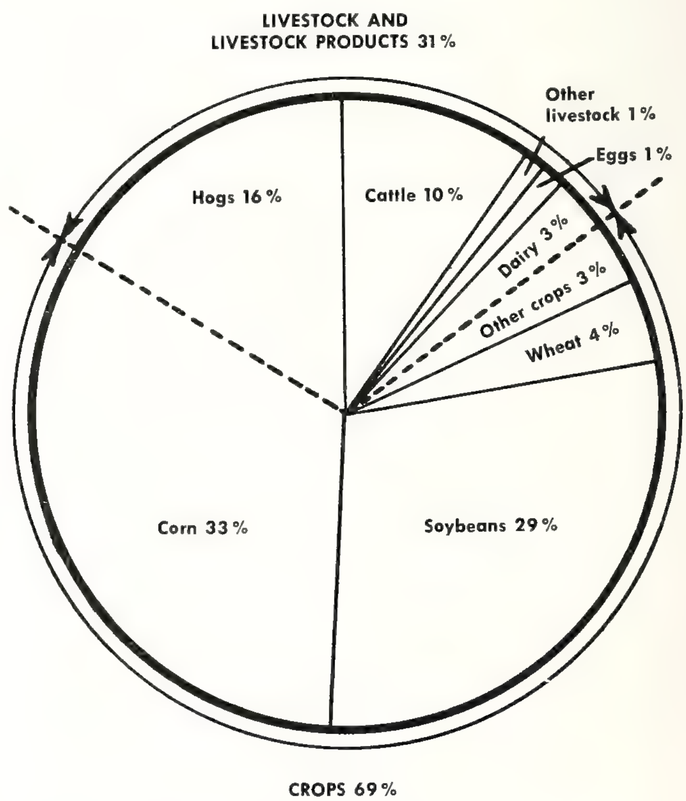
The volume of exports for the current crop year will likely reach a new high. In 1972 exports of corn jumped to a level of 1.25 billion bushels from the previous high of 800 million bushels. They have continued near this level and may possibly reach 1.5 billion bushels this year.

Illinois farm income has had the same upward trend. In 1974 Illinois ranked fourth among states, with $5.7 billion cash farm receipts. The leading states were: California, $8.7 billion; Iowa, $7.3 billion; and Texas, $5.8 billion. In crop sales, Illinois, with $3.9 billion, was second to California with $5.8 billion. In sales of livestock, Illinois ranked eighth with $1.8 billion. For major commodities, Illinois ranked first in sales of soybeans and second in both corn and hogs.

There is a definite trend for a higher percentage of Illinois farm income to come from crop sales. In 1974 crop sales accounted for 69 percent of cash farm receipts, with corn providing 33 percent and soybeans 27 percent (see chart at right). By contrast, in 1969 crops provided 50 percent of Illinois cash farm income. Corn contributed 27 percent and soybeans 17 percent.

Illinois will likely benefit even more from large crop sales in 1975. It was the leading state in corn production with a total of 1.2 billion bushels and a record acre yield of 116 bushels. With this large production and water and rail transportation that provides access to foreign markets, Illinois is in a most favorable situation.

Foreign markets are extremely important to U.S. agriculture. They are especially important to Illinois with its great production capacity. With rising incomes around the world, people are demanding diets with more animal products. To achieve this, many countries require more grain for livestock feed. As access to these markets is achieved, the prospects for Illinois farm incomes appear favorable. — *M. B. Kirtley, Extension economist*



Illinois cash farm income by commodity, 1974.

University of Illinois at Urbana-Champaign
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ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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County fairground facilities have potential for recreational use through much of the year (page 14).

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ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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(Cover picture by Paul Hixson)

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VISUAL AIDS TELL CENTENNIAL STORY

In the summer, 1975, issue, I reported that 1975 was the centennial year for the first agricultural experiment station in the United States. Since then, three special centennial articles have appeared in ILLINOIS RESEARCH. I now want to report that the Station has two visual aids for informing agricultural leaders and the public about some of the contributions that agricultural research has made to agriculture and to the nation.

The first is a 28½-minute color film entitled "Unfinished Miracles." This film was produced by the National Association of State Universities and Land Grant Colleges to tell the national story of agricultural research and the problems ahead. It is appropriate for rural and urban audiences of all ages. You may obtain it from the Visual Aid Service, 1325 South Oak, Champaign, Illinois 61820. A nominal fee of $5 is charged to cover handling costs. Your county Cooperative Extension Service staff can help you get the film if this is more convenient. Also, the Illinois Farmers Union and the Illinois Agricultural Association have purchased copies for use by members of these organizations.

The second visual aid is a 25-minute two-projector slide presentation with tape narration entitled, "Ag Research: The First 100 Years of Forever," which was developed by the Office of Agricultural Comunications to show some of the Illinois Station's contributions to agricultural development. This slide set is available from the office of each regional director of the Cooperative Extension Service.

The challenges facing agricultural research are fully as great for the next 100 years as they have been during the past 100 years. When the agricultural experiment station movement was started, this was an agrarian nation. Now, with less than 4 percent of the population on farms, the agricultural community is challenged to see that nonfarm audiences become aware of the problems in food production during the years ahead. We would encourage you to make whatever use you can of the above visual aids to help tell the story of agricultural research. At the same time that we tell the story, we dedicate ourselves to accepting the challenges that lie ahead. — *G. W. Salisbury*

Intercropping Soybeans And Sorghums in Oats

C. M. BROWN and D. W. GRAFFIS

Early stage of soybeans that have become established in oats. (Fig. 1)

DOUBLE-CROPPING is now an integral part of southern Illinois agriculture. After one crop is harvested, a second one is planted in the same field and harvested in the same year. Generally the first crop is a small grain and the second crop is soybeans, corn, or sorghum. Success of the practice varies from year to year, usually depending on the amount of available moisture when the second crop is planted.

Now interest in double-cropping is moving northward. Research at Urbana indicates that the practice can at times be successful in central Illinois. However, failures become more frequent as the northern limit of double-cropping is extended.

The farther north one goes, the greater the delay in harvesting the first crop and planting the second one. This increases the risk that there won't be enough moisture to establish the second crop. Also the crop is more likely to be immature at the time of the first killing frost.

Some cultural practices can improve the chances of establishing the second crop. Planting an early-maturing variety of small grain and drying the crop mechanically are two practices that will help shift the planting of the second crop to a period of more favorable moisture. No-till planting also conserves moisture for establishment and growth of the second crop. Despite these practices, however, double-cropping has continued to be highly risky in much of Illinois.

Intercropping — pros and cons

One way to extend the northern limit of double cropping may be by intercropping, or growing two or more crops in the same field at the same time. With intercropping, the second crop (intercrop) is established earlier than with the usual method of double cropping. Thus the second crop is more likely to have adequate moisture for establishment and has a better chance of maturing before frost damage. Cost of establishment might be much less, particularly if some of the equipment and herbicide costs can be eliminated or reduced.

Recently some innovative farmers have experimented with interseeding soybeans in winter wheat before the wheat is harvested. Usually the soybeans have been broadcast from the air, but sometimes they have been drilled directly into the wheat.

Some favorable results have been reported but failures appear to be more common. Most failures have been associated with inadequate seed distribution, failure of the soybeans to germinate and become established, and inadequate weed control in the second crop.

Oats as first crop

Because of the potential advantages of intercropping, experiments were conducted on the Agronomy South Farm at Urbana in 1975. The first crop was spring oats; the second, either soybeans or sorghum.

The land had been in soybeans the previous year and had been fall-plowed. Nitrogen was applied at the rate of 50 pounds per acre before the oats were planted.

Otee variety of oats was drilled in 8-inch rows on March 21 with a conventional grain drill. Planting rate was 2 bushels per acre. The early season was unusually cool and the oats took about 2 weeks to become established.

Soybeans as second crop

On April 29, Williams variety of soybeans was cross-drilled in some of the oat plots at the rate of 1.2 bushels per acre. Rows were 8 inches apart. A small experimental grain drill equipped with double disc openers and no supplemental covering or firming device was used. Within 2 weeks the soybeans became established in what appeared to be an adequate and uniform stand (Fig. 1).

In one treatment, the oats were harvested as silage on June 19. Stubble height was about 6 inches. Since the soybeans were then about 12 inches tall, parts of the plants were cut with the oats (Fig. 2). Most of the cuts were below the first trifoliate leaves and above the first unifoliate leaves. After silage was removed, the soybeans regrew, usually producing two branches per stem, one from the axis of each unifoliate leaf.

In another treatment oats were harvested for grain on July 10. By this time some of the soybeans were nearly as tall as the oats (Fig. 3) and the beans had begun to bloom and set pods. Fortunately, the oats did not lodge so it was possible to harvest most of the oat grain with a combine, clipping only the uppermost part of the soybean plants. After being clipped, the soybeans appeared to develop no further branch-

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Soybeans in oats just before the oats are harvested for silage. (Fig. 2)

Soybeans in oats near the time for oat grain harvest. (Fig. 3)

ing and remained at about the height of the cut stubble. However, podding on stems below the cut continued for some time.

The interplanted beans in the oats harvested for grain matured about 2 weeks earlier than those in the oats harvested for silage, and were only one-half to two-thirds as tall (Fig. 4). Harvest dates for the soybeans were September 30 (in oats harvested as grain) and October 14 (in oats harvested as silage).

The two mature soybean plants at left followed oat grain harvest; those on right, silage harvest. Note difference in height and number of pods. (Fig. 4)

Although no herbicide was applied, weeds did not appear to cause much damage. However, the experiment was conducted in an area where no serious weed problems were anticipated.

Oat and soybean yields

Silage yield of oats grown without the intercrop was 3,590 pounds of dry matter per acre, with 9 percent crude protein. For oats interplanted with soybeans, the yield was 3,777 pounds per acre of dry matter, with 9.6 percent crude protein. The soybeans thus appeared to slightly increase the yield and protein content of the silage.

Grain yield of oats grown alone was 95 bushels per acre; of oats interplanted with soybeans, 83 bushels. Part of the reduction in yield where soybeans were interplanted was likely caused by harvest problems, but competition from the soybeans could also have been a factor.

Soybeans yielded 40 bushels per acre after removal of an oat silage crop; 28 bushels after removal of an oat grain crop. Soybeans were not grown alone as a check treatment in this experiment, but Williams soybeans on nearby plots yielded 55 bushels per acre.

Although these results are from one year at one location, they suggest that intercropping soybeans in oats may be a good way of increasing cash returns on Illinois farms. Essentially the only additional cost inputs for the soybean crop were for seed, drilling, and harvesting.

Oats and sorghums

Grain sorghum and a sorghum × sudangrass hybrid were successfully established in oats by using about the same method as was used to interseed soybeans. Briefly, the interplanted crops were cross-drilled in the oats at 20 pounds per acre in 8-inch rows. Part of the oat crop was harvested as silage and part as grain. After the oats were removed, 75 pounds of nitrogen per acre was applied to the sorghum.

Oat silage yields averaged 3,590 pounds per acre and oat grain yields, 94 bushels. The interseeded sorghums had no significant effect on oat yields. After oats were harvested as silage, two cuttings of the sorghum × sudangrass produced 7,298 pounds of forage dry matter per acre. After oats were harvested as grain, two cuttings produced 6,388 pounds of dry matter. Grain sorghum yields were 4,815 pounds of grain per acre following oat silage and 3,676 pounds following oat grain.

More research needed

Although the 1975 results established that soybeans and sorghums can be successfully intercropped with spring oats, more research is needed to determine the feasibility of such a system. These are some questions that need exploring:

At what time and by what method should the second crop be introduced to get the maximum combined yield? What are the best planting rates, row widths, and varieties? Can winter wheat be substituted for oats as the first crop?

We will also need to know if poor weather conditions will drastically alter these findings. And we need to determine whether adequate weed control is possible in such an intercropping system.

Demonstration garden at Downers Grove.

Profits From Gardens

H. J. HOPEN

A HOME vegetable garden can have a sizable cash value, as indicated by records kept at demonstration gardens in 1975. The Department of Horticulture initiated these gardens in various parts of the state as a service to the increasing number of people who are attempting to grow some of their own food.

A small garden measuring about 750 square feet was located on the Pharmacognosy and Horticulture Field Station at Downers Grove. This garden was part of an extensive area demonstrating the culture of vegetables, fruits, and ornamental plants for gardeners in the Chicago area.

Larger gardens, measuring about 11,000 square feet, were planted at the University of Illinois Agronomy Research Center at Elwood, in northeastern Illinois; and at Shabbona, in north-central Illinois. Another large garden was planted at Belleville in the southwestern part of the state. It was grown in cooperation with the Belleville Area College and was located on the college grounds.

Locally adapted varieties were grown. They were selected from those listed in *Illinois Vegetable Garden Guide*, Illinois Extension Circular 1091. Pesticides were used to control insects and diseases as they became evident. Weed control was by mechanical cultivation, as is suggested for home gardens.

The garden at Downers Grove was about the size of many suburban and urban gardens. It was planted to crops that need only a small area to mature in. The larger gardens at Elwood, Shabbona, and Belleville had a wider array of vegetables and included crops that require more space, such as sweet corn and vining crops. These gardens were typical of many rural farm and nonfarm gardens.

In all gardens, maximum use was made of space by "double cropping" or planting a second crop after an early-maturing species was harvested. Crops harvested at Elwood are listed at right to illustrate the varied and continuing supply of vegetables that is possible.

Records of vegetable yields were kept throughout the season. Cash values were determined on the basis of representative 1975 retail produce prices. The people responsible for the work in the gardens either used the produce themselves or gave it away. Since people vary in their personal tastes and needs, the demonstration gardeners were asked to keep track of how much produce they kept for their own use.

The cost of seed and transplants would, of course, need to be deducted from the monetary value of the crop. In addition, home gardeners would have an initial investment for equipment, which would be minimal for a small garden. There would also be inputs for soil fertility, pesticides, and watering during periods of drouth and stress. Labor is usually thought of as recreation or a contribution to the family garden.

The Downers Grove garden produced an edible yield worth about $145. For the plants in this garden, with their low space needs, this was a return of about 19 cents per square foot. Investment in seed and transplants amounted to $11.50.

The Elwood garden, with an area of 10,800 square feet, provided an edible vegetable return of $870, of which $620 worth was kept for fresh use and processing. Total cash value amounted to about 8 cents per square foot before subtracting the seed and transplant cost of about $40.

At Belleville, the value of vegetables produced on 11,700 square feet was $630. This amounted to about 5.5 cents per square foot. Here $315 worth of produce was kept for fresh use and processing. Seed and transplant cost was about $35.

Meetings to demonstrate cultural practices for the home garden were held at all four locations in 1975. Similar meetings will be held this summer at Downers Grove, Elwood, and Belleville; and also at Brownstown (in south-central Illinois) and the Dixon Springs Agricultural Center. Your Extension adviser can tell you the dates of the meetings.

Crops Harvested From Elwood Garden

June. Rhubarb, green onions, radishes, head and leaf lettuce, spinach, broccoli, kale, mustard greens, peas

July. Broccoli, leaf lettuce, kohlrabi, mustard greens, cabbage, kale, New Zealand spinach, peas, summer squash, green beans, green and bulb onions, cauliflower, potatoes, cucumbers, spinach, green peppers, sweet corn

Aug. Green peppers, bulb onions, cucumbers, potatoes, summer and acorn squash, corn, cabbage, broccoli, eggplant, tomatoes, carrots, muskmelon, cauliflower, Brussels sprouts, watermelon, lima beans

Sep. Cucumbers, muskmelons, summer and storage squash, cabbage, tomatoes, Brussels sprouts, beets, watermelon, eggplant, potatoes, Swiss chard, peppers, kale, broccoli, lima beans, bulb onions

Oct. Cabbage, Brussels sprouts, radishes, tomatoes, cucumbers, summer and storage squash, eggplant, beets, broccoli, dry beans

H. J. Hopen is an Extension specialist in vegetable crops. The cooperation of W. F. Whiteside and Walter Staszak at Downers Grove, Greg Stack and Dale Harshbarger at Elwood, Richard Bell at Shabbona, and Richard Mann and Charles Geidemann at Belleville is sincerely appreciated.

A New Test for Milk and Water Safety

A partly automated procedure for detecting bacteria in milk and water samples is both speedy and accurate

LLOYD D. WITTER, JAMES W. MORAN, and TERRANCE L. SMITH

Consumers are entitled to expect that the food they eat and the water they drink will be free from disease-producing microorganisms called pathogens. Most food and water supplies are perfectly safe, and indeed their safety is simply taken for granted. But how can you tell if they are not? How can the food scientists test food and water for safety?

It is perhaps possible, although neither practical nor reasonable, to test a sample of water or food for all of the many, many potential pathogens that might be present. Each pathogen requires a special testing procedure, and some of the procedures are very difficult and time-consuming. The cost of completely testing any one sample would be very great indeed. Clearly, some other approach is necessary.

In the Department of Food Science, we have developed an approach that builds on work going back to the discovery of the bacterium *Escherichia coli* almost 100 years ago.

E. coli as an indicator

E. coli was discovered by Professor Theodor Escherich, who isolated it in 1885 from the feces of a cholera patient. Subsequently, he and others showed that this bacterium is uniformly present in the intestinal tract of man and other warm-blooded animals. He suggested that its presence elsewhere would indicate fecal contamination. Other scientists quickly accepted, repeatedly confirmed, and generally championed the use of *E. coli* as an indicator of fecal contamination.

The intestinal tract of man, as well as of other warm-blooded animals, is also the natural habitat of the many pathogens associated with food and water contamination. The presence of *E. coli* in food or water therefore indicated a strong likelihood that pathogens were also present. Hence, a single test for the presence of *E. coli* served as an index of food or water safety and would appear to have solved the problem of the food scientist.

E. coli was soon found to be so similar to several other closely related bacteria that it was difficult to distinguish *E. coli* from the others. Collectively, this group of bacteria, including *E. coli*, were called coliforms and simple tests were devised for their detection.

Of course, the coliforms had little sanitary significance since they comprised a mixture of bacteria of both fecal and non-fecal origin. Nonetheless this group has been employed for many decades to measure the sanitary quality or the acceptability of water, milk, and dairy products.

Over these decades, tests have been available to confirm whether the isolated coliforms were actually *E. coli*. Other tests have been available to indicate whether the isolated coliforms were of fecal origin without actually testing for *E. coli*. Either of these additional testing procedures certainly increased the accuracy with which one could evaluate the safety of a sample. However, they were time-consuming, delaying the results for at least an additional day. They also had certain technical limitations, and they increased the cost.

Needed improvements

With the advent of increased bacteriological testing as a measure of quality and safety, the food scientist has been pressured to improve the bacteriological testing procedures. In the last few years, three types of improvements in the coliform test procedure have been actively sought: (1) a reduced time for the test, (2) modifications that would allow the test to detect bacteria which have been injured or stressed by a process such as heating or freezing, and (3) the specific detection of fecal coliforms (nominally *E. coli*) and not just coliforms.

By combining the technical advancements and ideas of a number of other investigators, we developed a testing procedure which accomplished all three of the above objectives and in addition was partially automated.

Enzyme measures *E. coli*

Our test is partly based upon the 1940 discovery that *E. coli* possesses the enzyme glutamate decarboxylase. In the presence of glutamic acid this enzyme forms carbon dioxide as one of the products, and carbon dioxide is easily detected.

Subsequently, a number of coliform bacteria were tested for glutamate decarboxylase, but it wasn't found in any of them except *E. coli*. In France, H. Leclerc surveyed 230 different species and strains of bacterial cultures for glutamate decarboxylase. He found the enzyme only in *E. coli* and in a few other species

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and strains that were highly unlikely to be found in either milk or water. Further, he and P. A. Trinel devised an automated procedure to test for glutamate decarboxylase and suggested its possible use to indicate the presence of *E. coli* in water.

A reflection of a reflection

This automated procedure provided an indirect test of an indirect test. The determination of the presence of glutamate decarboxylase assumes that *E. coli* must also be present; the presence of *E. coli* indicates that the sample must have been exposed to fecal contamination; and the presence of fecal contamination suggests an increased probability that pathogenic bacteria are present.

While this may seem to be an extremely roundabout method of estimating the possibility of becoming ill by drinking water or by eating a particular food sample, such remote observations are not at all uncommon in everyday life. One analogous example is the inspection of the back of your head. The only way you can see it is in a reflection of a reflection, which is an indirect look at an indirect look at an object to be observed.

Testing procedure

Technicon Industrial Systems adapted their Auto Analyzer II system to automatically measure glutamate decarboxylase and made it available to us to evaluate its potential. We determined that this automated system was capable of detecting as few as 50,000 *E. coli* per milliliter. It was roughly 20 times more sensitive than the usual visible turbidity method of detecting growth of *E. coli* in test tubes. However, in a quality assurance program for milk or water it was necessary to detect as few as one cell per 100 milliliters.

This degree of sensitivity was achieved by inoculating a series of culture tubes with small measured aliquots of the sample to be tested, incubating the tubes until growth occurred (only about 10 hours to detect the presence of *E. coli*), detecting glutamate decarboxylase in each tube with the Auto Analyzer II, and determining the number of *E. coli* in the original sample. The number of *E. coli* was considered to be the most probable number in the original sample that would give the distribution of positive samples obtained in the series of culture tubes.

Table 1. — Comparison of Auto Analyzer Method With Other Methods of Detecting E. Coli (Percentage of organisms detected, with 100 percent assigned to Auto Analyzer)

Method	Stream water	Lake water	Chlorinated sewage effluent	Milk samples (aver.)
		percent		
Auto Analyzer method......	100	100	100	100
Standard method				
For water	100	68	76	...
For milk	...	...	...	70
Millipore filter method				
Present	66	34	22	...
Improved	84	41	64	...

Advantages of new test

The marriage of the most probable number technique with the automated procedure for detecting *E. coli* provides a procedure that is substantially better than the standard one. The new procedure is rapid, requiring only 10 hours; the standard procedure for detecting *E. coli* in water requires 48 hours for a presumptive test and 24 additional hours for confirmation of *E. coli*. With the new procedure, it is possible to detect injured or stressed organisms; the standard procedure does not provide an opportunity for injured organisms to recover. The new procedure is specific for *E. coli*; the standard one detects coliforms and detection of *E. coli* requires additional testing of the positive coliform samples. Lastly, the new procedure is partially automated.

Table 1 compares the efficiency of the Auto Analyzer method with the standard methods for water and milk, and with two millipore filter methods — the one now used and a proposed improved one.

The standard method for water is a most probable number technique; tubes are incubated for 48 hours and then each positive tube is confirmed for *E. coli* by an additional 24 hours of incubation under selective conditions. The standard method for milk is an agar plating procedure on a selective growth medium.

In the millipore filter methods, bacteria in a sample of water are retained on a filter membrane. In the present method the membrane is placed in contact with nutrients and the trapped bacteria grow, forming countable colonies. In the improved method the same procedure is followed except that several nutrient media are used to encourage growth.

The superiority of the Auto Analyzer method as shown in Table 1 was primarily due to its detection of injured or stressed organisms. Partial starvation probably stressed organisms in stream and lake samples, and chlorination probably injured the organisms in sewage effluent. The improved millipore filter method was specifically designed to recover injured organisms and, in comparison to the present millipore filter method, accomplished its purpose, but it was not as good as the Auto Analyzer method or even the standard method.

In the milk samples, the *E. coli* cells were efficiently enumerated by the Auto Analyzer method even though they comprised less than 1 percent of the total bacterial population. A high level of extraneous contamination did not appear to interfere with the test.

In view of the above results, this new test provides a rapid, efficient, partially automated procedure for estimating the sanitary quality of milk or water samples.

Swine Dysentery: Experiments Support New Theory as to Its Cause

R. C. MEYER

SINCE THE RECOGNITION of swine dysentery as a distinct clinical disease in Indiana over 55 years ago, it has become one of the most important contagious diseases of swine. Recently it has increased in incidence and severity. This is believed due to rising feeder pig production, extensive movement of swine between farms, and increased swine confinement. Losses to the pork industry in 1972 were estimated at 34 million dollars.

The word "dysentery" by itself is a general term, indicating that the large intestine is inflamed. "Swine dysentery," however, is more specific and limited in its meaning and refers to a specific disease.

The disease commonly strikes pigs 6 to 14 weeks old, although all ages may be affected. It usually expresses itself as a diarrhea. Feces from afflicted pigs are generally watery and contain mucus or blood (or both). Death losses may reach 30 percent or more in untreated weanling pigs, but the major losses are due to poor feed conversion and general unthriftiness.

R. C. Meyer is professor of veterinary pathology and hygiene.

Only recently has real progress been made in understanding swine dysentery. Research in the College of Veterinary Medicine has played a key role in clarifying misconceptions surrounding this disease.

Some misconceptions

Early investigators mistakenly believed that a bacterium, then called *Vibrio coli* (now *Campylobacter coli*), caused swine dysentery. Although one can argue the point, this misconception was probably a major stumbling block to our understanding the disease.

The attribution of the disease to *V. coli* is reflected in the use of such terms as vibrionic dysentery and intestinal vibriosis, which persist to this day. Various other terms have also been used, such as bloody dysentery and bloody or hemorrhagic scours.

A number of conditions with different causes, such as salmonellosis and heavy whipworm infestations, may be mistaken for swine dysentery. These conditions usually cause other signs and symptoms not present in true swine dysentery; nevertheless, they have contributed to the confusion surrounding this disease.

Another difficulty has been our conditioning by a long-established concept: one disease — one microbe. Although this concept applies to most diseases, we are learning that some diseases are caused not by a single agent, but by two or more distinct microbes working in concert.

We are not speaking here about simple mixed infections where the effects of the disease organisms are merely additive and the damage to the host is the sum of the organisms' individual activities. We are referring to those special cases where the total effect is greater than the sum of the parts. This type of infection is referred to as synergistic or synergic. It now appears that swine dysentery is such an infection.

A spirochete examined

The belief that *Vibrio* (*Campylobacter*) *coli* caused swine dysentery was called into question only a few years ago. As support for this theory declined, it was suggested that the causal agent might be a microorganism known as a spirochete. The evidence, however, was largely circumstantial and confirmation was lacking. Consequently we undertook a number of experiments to answer specific questions about the role of the suspected microbes.

Germfree pigs were used as experimental hosts. If a suspected spirochete was truly the cause of swine dysentery, it would be expected to produce disease in germfree pigs, since they lack passively acquired immunity and are highly susceptible to infectious agents.

The first study consisted of three trials with germfree piglets ranging in age from 5 to 20 days. The pigs were orally inoculated with cultures of a spirochete (*Treponema hyodysenteriae*) and *C. coli,* both reported to be the cause of swine dysentery. In two trials, the spirochete and vibrio were used alone and in combination. In the third trial, the two were used alone and the spirochete was combined with another bacterium, *Escherichia coli.*

No recognizable clinical disease resulted from exposure to any of the bacteria. The inoculated pigs remained normal throughout the trials. Their growth rates, hemograms, body temperatures, appetites, and feces showed no abnormalities when compared to those of germfree controls and other gnotobiotic swine exposed to nonpathogens. However, all the test agents readily colonized the intestinal tracts and were recovered from fecal specimens both during and at the end of each trial. These results raised questions as to the role of these agents in this disease, particularly since other investigators, using similar inoculum, reportedly reproduced swine dysentery.

Effect of microbial flora and diet

When colonization of the intestinal tract by *Treponema hyodysenteriae* and *C. coli* did not cause disease, we developed four hypotheses to interpret this result: (1) that the spirochete in question was either a nonpathogen or had been attenuated,

(2) that the agent was an opportunist or conditional pathogen requiring an unrecognized set of conditions or the interaction of other agents, (3) that the agent was a normal component of the intestinal flora and was not related to the cause of swine dysentery, and (4) that the diet modified the intestinal environment by some unrecognized mechanism to prevent the disease.

To test the validity of these hypotheses, additional experiments were conducted with special emphasis on the interaction of numerous intestinal microorganisms.

These trials showed the disease could be produced in germfree swine raised on a milk ration if colonic scrapings from afflicted pigs were used as inoculum rather than cultures of the spirochete. The results not only ruled out the milk ration as a modifier or preventive, but showed that other microorganisms, including some normally found in the intestine, must be present and active for the production of disease.

Role of selected agents

The evidence now strongly suggested that the clinical disease resulted from a mixed infection requiring the combined if not synergistic action of two or more agents. Then as at present, we had little information on the normal gram-negative anaerobic intestinal flora of swine, particularly as they related to the so-called fusobacteria and bacteroides and their actual or potential role in swine diseases.

One could find certain similarities, however, between swine dysentery and fusospirochetal, necrotizing infections of the mucous membrane in man. We therefore ran trials based on our earlier studies and existing knowledge about mixed anaerobic infections of the mucous membranes. A number of bacteroides and fusobacteria of swine origin were isolated and examined to determine their possible role in swine dysentery.

In these trials swine dysentery was, for the first time, successfully reproduced in a microbially defined host system with known pure cultures, but only when the bacteroides, fusobacteria, and spirochete were used together.

Results of this experiment provided conclusive evidence that swine dysentery is a synergistic infection due to the interaction of gram-negative obligate anaerobes (bacteroides and fusobacteria) and an intestinal spirochete. Whether other microbial agents besides the ones studied can fulfill the necessary requirements for disease production is still open to question, but, for the first time, the approach taken provides a means of identifying more precisely the actual agents involved in this disease.

The recognition of an interaction between several agents answers some of the questions about the occurrence of swine dysentery and why it does not always present a uniform clinical picture. Other agents may also participate in the disease process, modifying its course and severity and possibly even the effectiveness of different treatments. Controlling these agents may be as useful as controlling the agents responsible for initiating the disease.

When outbreaks occur in a herd it is often impossible to determine the source or origin of the infections. There is little doubt, however, that the disease is spread through the ingestion of feed and water contaminated with feces from infected animals.

Pigs vary considerably in their resistance and some are asymptomatic carriers. Usually, the disease will infect only a few animals at first, and may escape detection even by alert producers. As contact with infected feces increases in the pens, the infective dose builds up. More pigs become infected until the dose is high enough to infect even those with considerable resistance. At this point, a significant number of animals become involved, giving the impression of a sudden and explosive outbreak.

Prevention

The better the management and sanitation, the easier it is to control the disease, particularly if fattened pigs are put through as isolated batches. A direct relationship exists between the crowding of animals, the build-up of fecal wastes on the premises, and the recurrence and severity of the disease in a herd. If possible, infected animals should be isolated and given additional room. Where the disease exists, waterers and feeders should be elevated to lessen fecal contamination. Daily pressure hosing to remove fecal material from the feeding floors and slots of confinement buildings can facilitate recovery and prevent recurrences. Floor materials and designs with good self-cleaning characteristics appear to be of value.

To keep from introducing the disease, get your replacements from a few recognized breeders. Obtaining pigs from a wide variety of sources may introduce the intestinal microbial flora that can trigger the disease.

The use of organic arsenicals and antibiotics usually proves effective for the short term, and one might be tempted to regularly incorporate low levels of these medicants in the feed or water. This, however, can be counterproductive in the long run. Prolonged medication usually produces drug resistance in the microbes involved, with the loss of a previously effective treatment if the disease recurs.

Germfree pigs important

Although other investigators have speculated that more than one agent might be involved in swine dysentery, the work at the University of Illinois was the first to provide data in support of this theory. What a pig possesses in the way of an intestinal microbial flora appears critical and may very well determine whether disease will occur following exposure to one or more members of the complex.

It is doubtful whether any procedure other than use of the germfree pig could have demonstrated the relationship between the anaerobes and spirochete. The University of Illinois has one of the few facilities in the world for use of germfree pigs. These studies have again amply demonstrated the value of the facilities for veterinary research.

Freshening Without Calving

DALE E. BAUMAN, ROBERT J. COLLIER, and RAY L. HAYS

MILK PRODUCTION by dairy cows without an associated pregnancy and calving sounds strange. However, it is now possible to induce milk production in non-pregnant cows by injecting them with hormones.

How lactation is induced

Two hormones normally produced in the body of the cow are used in the treatment. These are progesterone and an estrogen, 17 β-estradiol. The hormones are injected under the skin twice a day for 7 days. The cost for each cow is less than $10.

Milking begins 21 days after the first injection. During this period dramatic changes occur in the mammary gland, as illustrated in Figure 1. The cow in this illustration was one of the more successful animals and reached a peak production of over 60 pounds of milk a day during her induced lactation.

The injections of estrogen and progesterone do not linger in the cow's body. Other investigators have demonstrated that these hormones are rapidly cleared from the body in the same way as hormones produced by the cow herself.

Our studies have shown that the milk from hormonally induced cows is identical in composition to that from cows undergoing normal pregnancy and lactation. During the first few days of lactation, induced cows produce colostrum milk just like normally lactating cows.

One difference is that hormonally induced cows take longer to reach peak milk production — about 8 weeks from the beginning of lactation. Once maximum production is attained, the persistency and length of lactation is about the same for hormonally induced cows as for normally lactating animals.

Unfortunately, not all cows induced into lactation respond with copious milk secretion. The variation in milk yield was indicated in one study of 16 cows and heifers (Table 1). On the average, about 75 percent of hormonally induced cows achieve a production greater than 20 pounds a day, and about 25 percent produce as much as during previous normal lactations.

Effect on reproduction

All the cows used in our induced lactation studies had been culled from the University of Illinois dairy herd for reproductive problems. These ranged from a lack of detectable heat periods to a failure to conceive after repeated breedings.

Would the induced lactations improve the cows' reproductive performance? To answer this question, nine of the most successful animals in Table 1 were bred (one or two services) while they were lactating.

Five animals conceived and had no complications during pregnancy. In fact, the two highest producing heifers in Table 1 are now in their first natural lactation and are projected to produce 15,000 to 16,000 pounds of milk for the lactation. Both have been successfully bred for the second time.

Mammary changes

The transition of a mammary cell from an inactive, resting state to a functional cell capable of milk synthesis represents a complex sequence of events. These involve changes in DNA, RNA, enzymes, intracellular organelles, and cellular membranes.

Using the cows that were being hormonally treated, we undertook a study of the different cellular events. Our purpose was twofold: (1) to establish the time periods in which the events occur; and (2) to identify differences in the tissue development of successful and unsuccessful cows. Mammary tissue was obtained by surgical biopsy at various times during the hormonal treatment. Various biochemical and histological changes within the tissue and fine-structural changes within the cell were examined.

After the hormone injections were started, the mammary tissue of all cows studied began changing from a nonfunctional state to a functional state capable of milk synthesis. In successful animals, the development continued to completion. In unsuccessful animals, however, the tissue did not complete the final stages of development. Instead, it began to regress in a manner similar to that occurring when a cow is dried off (that is, when her lactation is terminated).

The role of the injected hormones in these mammary cellular processes remains unknown. However, it appears likely that the induced lactation is due to an interaction between the injected hormones and the animal's endocrine system.

Explant system devised

In an effort to understand the role of hormones in the synthesis of milk, we devised an explant system. Small quantities of cow mammary tissue were incubated for several days in a medium containing the nutrients and oxygen that blood would normally supply to the cow's mammary gland.

By adding various hormones to the incubation medium, we could identify the ones required for tissue development. These turned out to be insulin, a corticoid, and prolactin. When they were added to the inactive mammary tissue, the cells became functional and began producing milk within 3 to 4 days.

Of these three hormones, insulin

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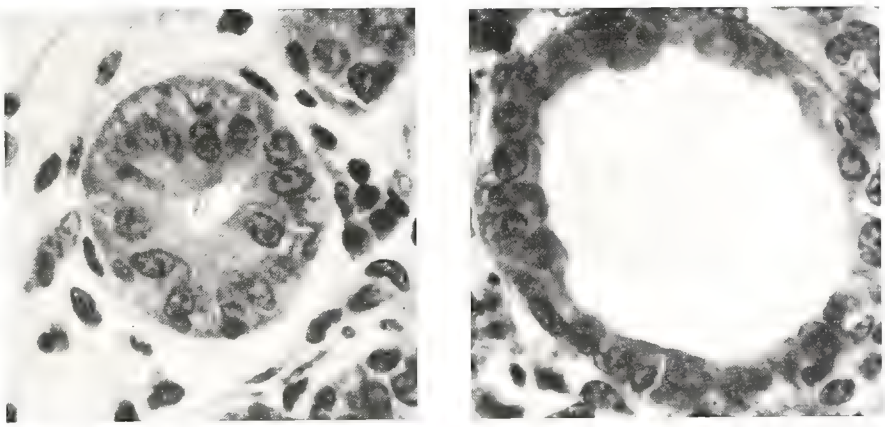
Table 1. — History and Lactation Performance of Cows and Heifers Hormonally Induced into Lactation

Animal	No. of previous lactations	Induced lactation peak milk yield, lb./day
1	2	71
2	1	68
3	0	40
4	0	38
5	0	35
6	0	31
7	0	29
8	0	29
9	4	22
10	2	22
11	6	20
12	1	9
13	4	9
14	3	4
15	4	< 2
16	3	< 2

Mammary gland just before hormonal treatment (*left*) and when milking began, 21 days after treatment (*right*). (Fig. 1)



Histological cross section of alveoli from mammary explants incubated with insulin plus cortisol (*left*) and with insulin plus cortisol plus prolactin (*right*). The lightly stained material in the lumen at right is milk protein, and with appropriate staining the milk fat droplets can also be seen in the lumen. (Fig. 2)

and the corticoid are needed to maintain the mammary explants. Prolactin is apparently essential for the mammary tissue to complete its development and start synthesizing milk.

The effect of prolactin is strikingly illustrated by the histological micrographs of mammary alveoli (the basic secretory units) in Figure 2. A mammary alveolus is comparable to a hollow rubber ball, with a single layer of mammary cells forming the surface of the ball. These cells synthesize the milk, which is secreted into the center or lumen. As long as insulin and a corticoid are the only two hormones provided, the alveoli remain compact with very small lumens. But after prolactin is added, the cells begin to synthesize milk components and the lumens of the alveoli expand as they are filled with milk.

These studies represent the first time that milk synthesis has been induced in cow mammary explants. On the basis of histological (Fig. 2), fine-structural, and biochemical measurements, the cellular changes in the explants appear identical to those occurring during the onset of lactation in the cow.

Studies are currently being conducted with the mammary explants to assess the role of estrogen, progesterone, and other animal hormones in the development of cow mammary tissue. Results with explants will then be applied in modifying the original treatment to hormonally induce lactation.

Future prospects

The Food and Drug Administration (FDA) will require extensive and expensive investigations before it will approve this method of inducing lactation. Our studies are conducted under experimental guidelines established by the FDA.

If approved for commercial application, the hormonal induction of lactation could be selectively used with problem breeder cows. Illinois dairymen cull about 25 percent of their lactating cows each year because of reproductive problems. Since high-producing dairy cows are under the most stress, many of the best cows are problem breeders. Inducing lactation in these cows would be a definite economic benefit.

Further benefits are anticipated. For example, this method of inducing lactation provides an ideal model for studying the role of hormones in the mammary gland's production of milk. Certainly an understanding of the endocrine involvement in milk synthesis offers many exciting possibilities for future application.

Some Differences Between Nuclear-Oriented and Extended-Oriented Families

CAROLYN P. RAETZKE and JEANNE L. HAFSTROM

When one homemaker talks of her "family," she will be thinking primarily of her husband and children. That is, she will be considering the nuclear family, which consists of parents and children living in one household.

Another homemaker, speaking of family, will likely be thinking of more than her husband and children. Her "family" is the extended family, including her parents, sisters, brothers, and other relatives, and those of her husband, regardless of where they live.

Do any differences exist between the families of homemakers oriented toward the extended family and of those who are nuclear-oriented? To answer this question, we studied data obtained during the 1970-71 Survey of Life Styles conducted in Champaign-Urbana. Some of the data from this survey of urban families helped us to determine the family orientation of 550 homemakers. Other data were used to relate various characteristics, expectations, and attitudes to the family orientation of the homemakers.

Households in the survey were limited to those with a mother or mother-substitute under 65 years of age and at least one child under 18. Student families were excluded. Households were stratified on the basis of the household head's occupation and were selected from the Champaign-Urbana City Directory by use of a random sampling technique. Information was collected from homemakers using an interview-questionnaire technique.

Carolyn P. Raetzke, a former research assistant, is now assistant professor of management and family economics, University of Kentucky; Jeanne L. Hafstrom is associate professor of family and consumption economics, University of Illinois.

Sample characteristics

For the 550 families in this study, the average number of persons per family was 4.6. Most of the families (93 percent) were white. Mean age of husbands was 37.5 years; homemakers, 36.5 years. Husbands, on the average, had completed 14.1 years of schooling; homemakers, 12.9. Average number of years married was 15.7. Median family income was $12,190.

Family orientation

To determine family orientation — or the importance of kinfolk — we used a modification of a scale developed by E. Litwak. Homemakers were asked to indicate the relative importance of four statements. These concerned the value of the family spending evenings together, having a house where the family could spend time together, having a location making it easy for relatives to get together, and having a house with enough room for parents to move into if they wanted to.

On the basis of homemakers' responses to these questions, 69 percent of the families were classified as extended-oriented; 31 percent as nuclear-oriented.

Family characteristics

Some significant differences were found between characteristics of families with a nuclear orientation and of those with an extended orientation.

Homemakers in nuclear-oriented families were more likely to be white than would be expected from the sample distribution, and were more likely to live in husband-wife-children families. In addition, they were more likely to have attended college, to have husbands and fathers who had completed 12 or more years of schooling, and to have fathers in white collar occupations. These homemakers were also more likely to be in the highest income group ($10,000 or more), to feel their family incomes were dependable, and to be very satisfied with their levels of living.

In contrast, more of the families classified as extended-oriented were black than would be expected from the sample, and more of them lived in non-nuclear families. The proportion of the homemakers having fathers in blue collar and farmer-

type occupations was higher than in the sample as a whole. Also higher were the percentages of homemakers who had stopped their schooling after high school graduation or earlier, who had husbands and fathers with 12 or fewer years of schooling, and who had mothers with 11 or fewer years of schooling.

The extended-oriented homemakers were more likely than would be expected to be in the lowest income group (less than $7,000) and to feel that their incomes were not dependable. They tended to be either somewhat satisfied or, to a lesser extent, dissatisfied with their levels of living.

Wants and expectations

Several differences in wants and expectations were found between homemakers in nuclear-oriented families and those in extended-oriented families. Homemakers in nuclear-oriented families were more likely to want their husbands to be doing the same type of work in one year. They also were more likely to plan on working themselves in 10 years' time. However, in the extended-oriented families, more of the homemakers wanted their husbands to be in a different type of job than would be expected from the sample distribution. And more of them did not know if they would be working in 10 years.

In addition, homemakers in nuclear-oriented families were inclined to want their sons to do the same type of work as their husbands and to want their daughters to marry someone with occupations like those of their husbands. By comparison, homemakers in extended-oriented families were more likely to want their sons to do different types of work than their husbands and to want their daughters to marry men whose occupations were different from those of their husbands.

Child- and home-related attitudes

Homemakers were asked to react to a number of statements reflecting attitudes toward children and the home. Reactions to the following attitude statements were significantly related to family orientation:

(1) Respect for parents is the most important thing kids should learn. (2) Most kids should be toilet-trained by 15 months of age. (3) Children should be nicer than they are to their mothers since the mothers suffer so much for the children. (4) Most kids should be spanked more often. (5) It's not all right for boys and girls to see each other undressed before age 5. (6) A child should be taken away from the breast or bottle as soon as possible. (7) The main goal of the parent is to see that the child stays out of trouble. (8) It is more important to have a well-run home than lots of friends to visit with.

Homemakers in extended-oriented families were more likely to agree with these statements than would be expected, while homemakers in nuclear-oriented families were more likely to disagree.

Family decisions

One group of questions concerned decision-making — whether the husband, the wife, or both together made the decisions on a variety of matters. Three types of decisions were significantly related to family orientation: those concerning the best place for the family to live; how the money is used; and who handles the money.

When the family was nuclear-oriented, either the husband or the wife alone was more likely to decide on the place to live and how the money was used, but when the family was extended-oriented both the husband and wife were more likely to make these decisions. In addition, in nuclear-oriented families the wife was much more likely to handle the money, while in extended-oriented families the husband or both spouses were more likely to do so.

Relative interactions

All seven of the relative-interaction variables used in this study were significantly related to the Modified-Litwak Family Orientation Scale. As might be expected, a much larger percentage of extended-oriented families than of nuclear-oriented families had relatives within easy visiting distance.

Nuclear-oriented families were more likely to neither get help from nor give help to relatives than would be expected from the sample. They were inclined not to discuss problems with relatives and to spend less time visiting with relatives than with people not related to them.

By comparison, extended-oriented families were more likely than would be expected from the sample distribution both to get help from and to give help to relatives. They were also more likely to talk over their problems with relatives, and to spend more time visiting with relatives than with people not related to them.

In the majority of nuclear-oriented families, none or only one or two of the most frequent visitors were relatives. Few of these families visited with relatives as often as every month.

In extended-oriented families, it was more likely that three or more of the most frequent visitors would be relatives. These families were also more likely to visit with relatives three or more times a month.

Rural vs. urban background

It was expected that families in which the homemaker and husband had rural backgrounds would most likely be extended-oriented, while the opposite would be true of families in which the homemaker and husband had urban backgrounds. However, these variables were not significantly related to family orientation.

Value of study

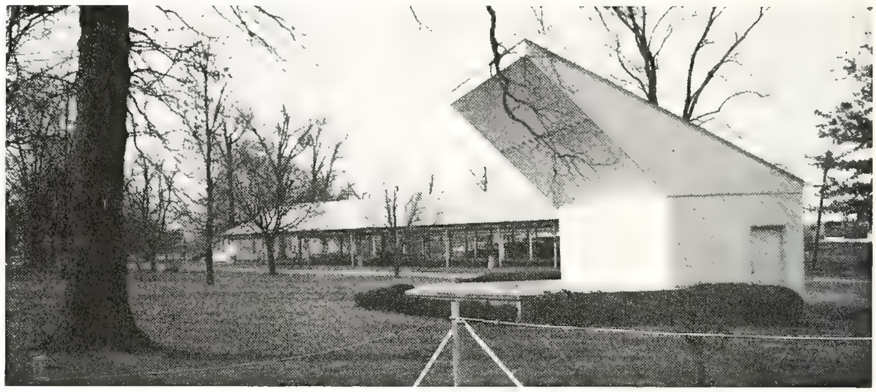
Results of this study indicate that significant relationships exist between many types of variables and the classification of a family as nuclear- or extended-oriented. This information should provide valuable insight for Extension advisers and others who work with families of different orientations.

COUNTY FAIRGROUNDS: Their Recreational Potential

ROBERT D. ESPESETH and RONALD A. VINE

COUNTY FAIRS continue to be focal points of rural society, not only in Illinois but throughout the country. At present, 102 fairs are operating in 90 Illinois counties under the auspices of the State Department of Agriculture, Division of County Fairs.

Many of the fairgrounds are beautiful pieces of property located in or adjacent to cities or towns. Some of them are used extensively for community activities; others sit idle except for a few days a year.



This Richland County park includes recreational facilities and a fairground.

Recreational facilities needed

It seems reasonable to assume that fairgrounds could be more fully utilized to help meet the recreational needs of the state. These needs are already great, and the demand for park and recreational opportunities is rapidly expanding.

It has long been recognized that every level of government, as well as private industry, has a role to play in meeting the demand for recreational space and facilities. Local communities have traditionally provided playgrounds, neighborhood parks, community centers, and recreation programming. Many counties have provided larger parks away from urban areas, focusing on natural areas with more limited recreational facilities. State and national park systems have set aside very large tracts of particular historic, scenic, or natural significance.

Even with a combination of local, county, and state parks, Illinois ranks forty-sixth among the states in available recreational land per capita. The state does not have enough recreational areas and facilities to meet current needs of its large population, let alone future needs.

Survey made

To get an idea of how much county fairgrounds could contribute to Illinois's recreational needs, we sent questionnaires in 1973 to the fair associations or governing boards of all county fairs in the state. Questions were designed to determine the fairgrounds' existing facilities, present use patterns, and potential uses. Responses were received from representatives of 93 fairs.

Size, organization, and use

Over 80 percent of the state's fairgrounds are administratively controlled by fair associations; the others are governed by 4-H, Chambers of Commerce, or county or village boards. Seventy-four of the fair associations or governing bodies own their own fairgrounds. Altogether, they own 4,709 acres for an average of about 63 acres per fair. The other 28 fairs lease a total of 774 acres, for an average of about 28 acres. (Ownership or lease data for fairs not responding to our questionnaire were obtained from the 1973 Recapitulation of the Reports of the Agricultural and Industrial Fairs of Illinois.)

According to the 93 respondents, the average fairground was used only 8.3 days a year for fair activities and 61.9 days for non-fair activities. Only 35 fairgrounds had a non-fair use of more than 40 days a year, and only 11 had a non-fair use of more than 100 days. Composite average use was 5.9 days per month, meaning that the average fairground sits idle about 80 percent of the time.

Location and facilities

Most fairgrounds are flat to gently rolling, with limited tree cover. Several respondents reported ponds or streams either within the site or on the periphery. As a rule, the fairgrounds are located close to a town or city, with some having substantial populations within a 15-minute drive.

Of the 93 fairgrounds about which we received information, 83 had covered shelters; 79 had enclosed but non-winterized buildings; and 45 had winterized buildings. This amounts to a tremendous area under roof that could be available for many uses.

All but 10 of the 93 fairgrounds re-

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A hockey game at the McDonough County fairground.

ported having flush toilets; 29 had pit toilets. Hot water and showers were available at 54 fairgrounds.

Race tracks seem to be an important part of the fair operation and atmosphere, as 58 of the fairgrounds had either quarter- or half-mile tracks. Average seating capacity in permanent seats was 2,423. Harness racing was scheduled at 43 tracks and running races at 24 tracks.

Permanent snack bars were reported by 44 fairgrounds. A total of 80 kitchens was reported at 55 fairgrounds. The number of kitchens correlates closely with the number of winterized buildings, indicating that most of these buildings contain cooking facilities.

Although 41 respondents indicated that picnicking was permitted, only 28 indicated a specific number of picnic areas. The highest number of tables reported was 120, indicating substantial picnic use.

Since most people come to fairs in private cars, a large amount of parking space is needed. The fairgrounds had space for an average of over 1,100 cars per fairground, with 80 percent indicating that the space was on grass areas. Parking was also available outside many of the fairgrounds. Only 34 fairgrounds charged a fee for parking.

Over 90 percent of the fairgrounds reported an adequate supply of drinkable water. Of these, 82 percent used public water systems and 18 percent used their own wells.

Investment

The amount of money invested in land and facilities is substantial. Investment in land for 59 fairgrounds averaged $52,975 per fairground and ranged from $6,000 to $200,000. Investment for facilities, reported for 72 fairgrounds, averaged $130,931, with a range from $15,000 to over $1,000,000.

Total investment reported by the fairgrounds participating in this study was $12,800,000. The total for all fairgrounds, as reported by the Division of County Fairs in 1973, was $17,200,000.

Cooperative efforts

Respondents gave several good examples of fairgrounds being cooperatively used for community benefits, or of community land being used as fairgrounds.

The fairground for Richland County is located in the large community park in Olney and is leased from the city during the fair. There are ball fields inside the race track and the grandstands are used for games and other events, as well as racing. Horse barns and other structures are leased out when not being used for the fair. The entire park is used throughout the year as part of the Olney park system.

Through the efforts of the fair association in Franklin County and their interest in donating the 40-acre fairgrounds to a responsible agency, a park district was formed in Benton. This land is available to provide immediate use to local citizens.

The Tazewell County fair facilities are constructed on land leased from the Pekin Park District. During periods when the facilities are not being used by the fair association, they are rented out to other groups. One of the fair structures houses an ice rink operated by the Park District.

A McDonough County fair official reported heavy use of the fairgrounds throughout the year and commented, "We've had everything except a wedding or a funeral." (Since then a wedding has been held there.) Several counties reported 350 or more days of use but did not elaborate on the type of use.

Despite these examples of cooperation, most of the respondents indicated that their fairgrounds were not included in the municipal or county recreation plan. The majority also indicated that they did not have cooperative agreements with any recreation agencies. Only 25 percent had written policies on the use of their fairgrounds.

Most respondents agree

Most respondents felt that fairgrounds did have land available which could be used for recreation. Of those who answered a question as to the need for additional recreational facilities in their counties, 72 percent indicated that there was such a need.

It would be to the general benefit of the local citizens if fair associations would give greater consideration to the potential use of the fairgrounds for additional recreation or other community functions. Cooperative agreements could be worked out with local agencies to assist the fair association in maintaining, supervising, and improving the facilities. It is also recommended that fair associations adopt written policies that outline all fees, policies, rules, and regulations.

Grain Drying Studies Are Continued in A Special Facility

GENE C. SHOVE

Arid, humid, hot, or cold environments may not be too appealing as one considers an ideal place to work and live. However, such conditions do exist and their effects on agricultural production and processes are of great concern to biologists and engineers.

Research to evaluate the effects of environment is often disconcerting because it is difficult, if not impossible, to control environmental conditions. Fortunately, a new facility at the University of Wisconsin provides computer-controlled environments for biological and related research. During a recent sabbatical leave, I was able to use this facility to continue studies on drying grain at low temperatures.

The Biotron

The Wisconsin facility, known as the Biotron, was opened in 1968. It was made possible by funds from the National Science Foundation, the National Institutes of Health, the Ford Foundation, and the State of Wisconsin. Its facilities are available, on a fee basis, to scientists from all over the world.

The Biotron contains nearly 50 rooms ranging in size from 4 by 8 feet to 9 by 31 feet. Within these rooms it is possible to exercise selective control over the various elements of the physical environment, such as air and soil temperatures, atmospheric moisture, light, air velocity, and sound.

In one room, even variations in atmospheric pressure can be duplicated. A crossed gradient room provides a light gradient along one axis and an air temperature gradient at right angles to the light gradient. A wind tunnel room and sound-isolated rooms are available. Low relative humidities, high temperatures, and variable wind velocities create desert conditions in another room. In short, the Biotron can duplicate environments almost anywhere in the world, while freeing the researcher from the mechanical and housekeeping duties involved in maintaining the environment.

Room used for studies

In 1972-73 a University of Wisconsin graduate student used the Biotron to study low-temperature drying of corn under adverse Wisconsin weather conditions. The 16-foot grain columns built for his study were available for my investigations the following year. The room housing the grain columns was provided with an artificial weather cycle representing the daily fluctuations in air temperature that would be expected in Illinois.

Acid treatment

In one study, adding propionic acid to wet grain eliminated fungal growth, permitting the grain to be dried with low airflow rates over extended periods of time. The low rates don't require as much equipment as higher rates, but this advantage is often offset by deterioration due to fungi in untreated grain.

After the corn was dried, the acid residue was found to be about 50 percent of the amount applied. Propionic acid cannot be tolerated in grain for food, so acid preservatives are currently used only for grain to be fed to livestock.

For the livestock feeder, treating wet grain with about 0.3 percent (by weight) of propionic acid will double the allowable drying time. It will also allow wetter grain to be held for feeding purposes than would otherwise be possible.

Temperature cycling

A second study was set up to determine the benefits, if any, of temperature cycling, which consists of varying the temperature of the drying air. Results were variable. In some of the experiments, the moisture content was gradually reduced throughout a stationary column of drying grain. Other experiments, however, did not show this benefit.

Until further investigations definitely prove temperature cycling to be beneficial, its use will be based on other advantages. For example, if an "off peak" electrical energy rate can be obtained by operating heaters only at night, there would be an incentive for such a mode of operation. The result, of course, would be a variation in the temperature of drying air.

Airflow rates

Another series of Biotron investigations substantiated the minimum airflow rates for drying shelled corn when average daily temperature is below 50°F. Following are the minimum airflow rates for five corn moisture contents: 28 percent, 5 cfm per bushel; 26 percent, 3 cfm; 24 percent, 2 cfm; 22 percent, 1¼ cfm; 20 percent, 1 cfm.

Exact drying times are difficult to predict because of varying weather conditions. However, the approximate times to dry corn with various moisture contents are: 28 percent, 2 weeks; 26 percent, 3 weeks; 24 percent, 4 weeks; 22 percent, 5½ weeks; and 20 percent, 6 weeks.

Low temperature drying is a proved method of drying grain and may need to be considered more seriously as energy for higher heat systems becomes less available and more costly.

Gene C. Shove is professor of agricultural engineering.

Forestry Research Changes Direction At Dixon Springs Agricultural Center

L. E. ARNOLD and G. L. ROLFE

FORESTRY RESEARCH at Dixon Springs Agricultural Center (DSAC) has been going on since the early 1940's. By now more than 20 research areas, ranging in size from about half an acre to 50 acres and totaling more than 250 acres, are under study.

So far, much of the forestry research at DSAC has dealt with various aspects of forest production. The first project was to plant pines in open areas and initiate studies on the silvicultural and economic management of these plantations.

Other studies beginning in the 1940's concerned the effects of different management practices on wood yield and quality of native hardwoods in southern Illinois. In 1947 a series of stake- and post-decay studies was initiated.

Some of the major studies have been yielding data for 25 years on the management of pines and native hardwoods in southern Illinois. For example, studies have been carried on since the early 1950's to determine the spacing that would produce maximum volume yields of shortleaf and loblolly pine when these species were grown in plantations.

New emphasis

The emphasis of our current research has been shifted to studies more in tune with today's needs. This change does not minimize the value of the earlier studies, but it is the next logical step in a well-ordered research program.

At present, research is concentrated in four areas: (1) the interrelationships between soil characteristics and tree growth; (2) the nutrient cycling pathways in various types of southern Illinois forests; (3) waste disposal in forested environments; and (4) effects of various forest management and silvicultural practices on water quality and yield.

Soil and tree growth

Projects have been designed to learn how soil conditions, such as soil moisture, holding capacity, organic matter content, and cation exchange capacity, have affected tree growth. Conversely, we have also studied the effects of tree species on soil conditions. Since these studies have been under way for the past 10 to 15 years, many relevant questions have already been answered.

In a more recent addition to the research on soil-plant interrelationships, liquid livestock waste is being added to forest soils. The effects on both tree growth and soil conditions are being monitored.

Nutrient pathways

In the second area of research, the aim is to identify the pathways by which shortleaf pines, loblolly pines, and mature oak-hickory forests cycle nutrients. These studies are yielding data on nutrient uptake and storage in the biota and the rates of nutrient return to the soil system. This type of information is valuable for assessing the long-term demands that various timber-production strategies will make on the soil-nutrient supplies.

Waste disposal

The third major area of research centers around the possibility of using forested and agricultural watersheds to inexpensively dispose of liquid waste from a cattle feedlot. Perhaps we can use forested areas for waste disposal without damaging the forest or affecting the quality of drainage waters. In addition, such benefits as increased tree growth and improved site productivity may result from the added nutrients and moisture in the waste.

Water quality and yield

In the fourth research area, we are concerned with water quality and yield as they are affected by various forest-management practices and by the growing and tending of trees. Two pertinent questions are: What are the short- and long-term effects of thinning and clear-cutting pine plantations on water quality and yield? Do these practices cause site deterioration or are they environmentally acceptable?

These studies include both hardwood and coniferous forests, as well as abandoned field sites, that are under a range of management alternatives. They will yield data that are necessary for long-term maintenance of site productivity.

Future plans

The future forestry research program at DSAC will continue to give priority to solving environmental problems relating to Illinois and problems concerning land use. We will be particularly concerned with areas having wildland resources. Our prime objective is to insure that the forest and the forest environment are maintained as renewable resources for the use of future generations.

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4-H Leaders Learn From Sound Sheets

J. A. SCHERER, C. M. SCHERER, and G. L. DAIGH

LEARNING to be a volunteer 4-H leader has become an at-home listening experience in Illinois.

Through a special grant from the Federal Extension Service, the Illinois Cooperative Extension Service has developed a two-unit 4-H leader training program and recorded it on vinyl sound sheets. The series is entitled "Helping You Help Youth."

Previously, in training 4-H leaders, Extension advisers had to rely entirely on conventional methods — meetings, workshops, newsletters, and individual conferences. Yet studies revealed that almost half of the local leaders did not attend leader development meetings, often because the meetings were held at inconvenient times or places.

The project developers hypothesized that volunteer leaders who will give time and energy to the 4-H programs are also willing to spend time preparing to be a more effective volunteer, if they can do so at their convenience. The result of this thinking was the vinyl sound sheets.

What the units include

A vinyl sound sheet is a thin sheet of plastic with a recorded message on both sides for use on a phonograph. The two units contain 11 sound sheets, each having about 20 minutes of recorded instruction. The set of sheets for each unit is enclosed in a cardboard folder. This folder provides space for quizzes, crossword puzzles, games, references, sample programs, checklists, and questions to stimulate thought.

Unit I is designed mainly for new volunteer leaders. It covers these topics: the role of the volunteer leader, the history and philosophy of 4-H, how to conduct a 4-H meeting, arranging learning situations, understanding youth, projects and activities available to youth, and a sharing of ideas that have worked for experienced leaders.

Included in this unit is a telephone interview with Dr. Evelyn M. DuVall, nationally known author and lecturer. This recording is entitled "Understanding Boys and Girls Ages 16 Through 19."

The sound sheet on ideas that work contains recorded interviews with volunteer leaders, as well as with specialists and recognized leaders in the field of youth development. It includes more than 30 suggestions from local leaders.

Unit II, intended for experienced leaders, covers values, group dynamics, program planning, and awards and incentives. Suggestions for the use of various teaching tools and techniques, for recreational activities, and for publicizing 4-H in the community are incorporated. And because the importance of parents in any youth activity is often forgotten, this unit stresses the value of involving parents in 4-H.

Use and reactions

The personalized self-instruction possible with the vinyl sheets has proved very workable and helpful. One leader has said, "I feel I learned more from these [the records] because they could be played repeatedly and when I had the time to really sit and listen."

New leaders using the sound sheets have commented that the discussions about ideas are especially beneficial. Experienced leaders have said that the series reassured them of their capabilities and stimulated them to use different approaches in working with youth. In one leader's words, "The meeting series provided an excellent review on making the leader realize that the program must start with the youth's needs — at his level and interest."

Although the records were produced for individual study, leaders have been using them in other interesting ways. One held a parents' night, inviting parents of 4-H'ers in her club to come and listen and learn. Both the leader and the parents felt that the evening was very successful. Another leader used the sound sheets with junior leaders and advisory council members.

Meeting packet

The team developing the project realized that records cannot duplicate the communication possible in face-to-face meetings. Therefore, they developed a series of meeting packets for county Extension advisers to use with volunteer leaders. The packets contain 800 slides in 13 sets with recorded scripts, 65 overhead transparencies, and a number of reference sheets. They also incorporate suggestions for games, exercises, discussions, and the use of group dynamics.

Supplementing the packets are notebooks containing additional materials for Extension advisers conducting meetings for volunteer leaders. These materials include planning guides, lesson outlines, discussion guides, evaluation forms, lists of needed supplies and equipment, and a bibliography of reference materials and resources.

Wide application

It is hoped that, by listening to the sound sheets or attending leader development meetings, volunteer leaders will experience fewer frustrations, remain leaders longer, and receive more satisfaction from their service than in the past.

Many other states are now using the sound sheets in their 4-H program. The information and many of the techniques covered in the two units also have value for any youth agency that is dependent on volunteer leaders.

J. A. Scherer, now subject matter coordinator for Consumer and Homemaking Education Program, and C. M. Scherer, Extension communications specialist, were project producers. G. L. Daigh, 4-H specialist, was project director.

Five Receive Funk Awards

Five College of Agriculture staff members were honored February 27 in the sixth annual Paul A. Funk Recognition Program. Under this program, cash awards are provided by the Paul A. Funk Foundation of Bloomington "to recognize outstanding performance and high achievement among the faculty of the College of Agriculture at the University of Illinois."

The major achievements of the award members are briefly summarized in the following paragraphs.

Chester Bird Baker

Dr. Baker is internationally known for his innovative research in agricultural finance and production.

His many publications on the interdependence of production, financial, and marketing decisions have yielded important insights into structural changes in farm production. As a teacher, he has instilled in his students his own high standards of excellence. Many of his former students now hold responsible positions in various parts of the world.

Dr. Baker has served as adviser to the Bureau of Indian Affairs and the Tennessee Valley Authority. In 1968 he was leader of a group that prepared a report on agricultural finance and land tenure for the Canadian government. He has also been consultant to the Illinois Council for Branch Banking, the Midwest Research Institute, and the National Association of Food Chains. In 1975 he received an Ernest H. Wakefield Award from the University of Illinois for outstanding achievement.

Carl Lee Davis

A leading scientist in ruminant nutrition, Dr. Davis has established principles that are used by producers and taught in dairy science courses throughout the world.

He and his co-workers were the first to determine production rates of volatile fatty acids in the rumen and the animal's utilization of these substances for energy. His classic research in this area is the basis for studies which have led to current feeding recommendations.

Dr. Davis has been a leader in testing theories of milk-fat depression and has discovered that bicarbonate can alleviate the condition. He has also done major research in a number of other areas. In recognition of his research accomplishments, he received the American Feed Manufacturers' Award in 1971.

He often consults with Extension staff on nutrition problems and is also an excellent teacher, with the ability to stimulate thought and creativity in his students.

David Gottlieb

Dr. Gottlieb has gained world renown for his research on antibiotics and fungal physiology. He is also an international authority on the taxonomy and nomenclature of actinomycetes, the microorganisms that produce most of the antibiotics.

He has improved techniques for isolating and producing streptomycin; he and his colleagues were the first to isolate the antibiotic filipin among others; and they were co-discovers of chloramphenicol. In studying filipin, he generated information about its effects on membranes that has enabled others to study the membranes of many living systems.

His studies on fungal spore germination have made it easier to predict and control fungal plant diseases. His work on changes in fungi during aging provides important clues for studies of aging in other organisms.

Dr. Gottlieb is an inspiring teacher, many of whose students have gone on to outstanding careers of their own.

George Elvert McKibben

During 30 years at the Dixon Springs Agricultural Center, Professor McKibben has contributed immeasurably to the agriculture of southern Illinois and of similar areas.

He is especially noted for his pioneering work on zero-till crop production, which he began in 1962. With zero-tillage farmers get high yields of corn and soybeans on land too steep for conventional tillage. Today, zero-tillage makes its greatest impact through double-cropping of soybeans in wheat stubble.

Before his work on zero-tillage, Professor McKibben tested and advocated practices that converted the eroded soils of southern Illinois into productive pasture lands. Soil improvement through pasture and livestock production logically had to precede intensive zero-cropping.

Professor McKibben's close rapport with farmers, businessmen, and fellow workers has greatly helped to spread economic agricultural practices throughout the southern Corn Belt.

Zakarias John Ordal

Dr. Ordal is an outstanding microbiologist whose long-time studies on the spores of food spoilage organisms have earned him an international reputation. He is also well known for his research on the heat resistance of bacterial cells and their recovery from injury. Because of his work in these areas, new standards for examining food products for microorganisms are currently being adopted.

A third area of research — the control of spoilage in fresh meats — has led to the commercial use of oxygen-impermeable films for packaging meats.

He is a highly successful teacher, whose former students hold prominent positions worldwide. For many years he served on numerous panels and advisory committees of the National Institutes of Health. He has also been on many committees of the Institute of Food Technologists and was recently elected a Fellow of the Institute.

FARM BUSINESS TRENDS

As PLANTING TIME approaches, costs of farmers' production items are, on the average, about 8 percent higher than they were a year ago. However, some items have decreased in cost and others have remained the same.

Fertilizer prices are expected to be as much as 25 percent less than in 1975, and supplies will probably be more abundant than they were last year.

Because of the number of new nitrogen plants built during the past year, nitrogen supplies could be almost 20 percent greater in 1976 than in 1975, but current price levels may limit increases to about 5 percent. Increased acreages of corn and cotton should result in a larger demand for nitrogen in 1976 than in 1975.

U.S. phosphate manufacturers are capable of producing over 9 million tons of phosphate in 1976. This is 50 percent more than the 6 million tons projected for domestic and export demand this year.

Potash supplies in 1976 should about equal the demand. About three-fourths of our needs will be supplied from Canada and the rest will be produced domestically.

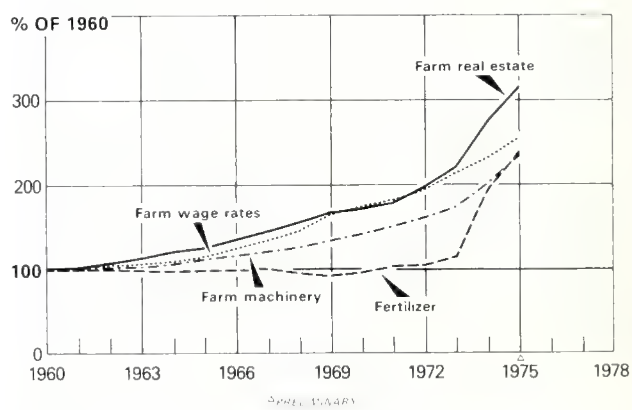
Pesticide manufacturers may increase production 10 to 15 percent over 1975 production. Over all, inventories have improved from a year ago. Pesticide needs will be increased about in proportion to the increased acreages in crops. The larger supplies of pesticides are holding prices near last year's levels. In some areas prices are slightly down this spring.

Gasoline and diesel fuels are in adequate supply for agriculture. Gasoline prices have increased about 14 percent during the past year and diesel fuel prices, about 7 percent. Since the first of the year prices of both fuels have been reduced a cent or two in some sections of the state. Price increases can be expected in the longer run since about two-fifths of our supplies are imported and costs of discovery of domestic supplies continue to rise.

Interest rates on non-real estate loans have declined from the peak in 1975. Rates charged by commercial banks are down considerably. Rural bank rates, while fluctuating less than those of large commercial banks, have also declined since last year's high. Interest rates charged by Production Credit Associations were about 1 percent lower in January, 1976, than a year earlier. The declines in interest rates charged by the major lenders will significantly affect the interest paid by farmers in their operating loans.

The average number of workers on Illinois farms increased about 4 percent from 1974 to 1975. This may indicate a change from the long-time downward trend in the farm labor force. With the unemployment rate at 7½ to 8 percent, farm labor may be more available this spring and summer. Farmers can often pay well above the hourly rate to get crops in on time. Hiring additional help to run machinery and equipment longer hours can pay high dividends.

The general slowing in price inflation, as well as lower prices for many farm inputs, will contribute to a favorable income position for farmers during the first half of 1976. — *R. B. Schwart, Extension economist in farm management*



Prices of selected farm inputs, 1960-1975.

University of Illinois at Urbana-Champaign
Agricultural Experiment Station · G. W. Salisbury, Director
Urbana, Ill. 61801 · Publication · 12M

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ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

IN THIS ISSUE

Early in this century, the appearance of round barns throughout the state represented one of the earliest impacts made by the Department of Dairy Science on the dairy industry (page 14).

COLLEGE OF AGRICULTURE Volume 18, Number 3

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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(Cover picture by Larry Baker)

Summer, 1976 Volume 18, Number 3

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G. W. Salisbury....................Director
Margery E. Suhre....Editor, ILLINOIS RESEARCH

To receive ILLINOIS RESEARCH free of charge, write to the Agricultural Publications Office, 123 Mumford Hall, Urbana, Illinois 61801.

REDEEMING A LOST HERITAGE

In keeping with the nation's Bicentennial year, the Illinois Agricultural Experiment Station and Cooperative Extension Service have just published a book that enhances our knowledge and appreciation of the past. The book is *Redeeming a Lost Heritage,* a history of southern Illinois agriculture in general and of the Dixon Springs Agricultural Center in particular.

Before the Center (originally known as the Dixon Springs Experiment Station) was started in the 1930's, the agricultural research conducted by the University of Illinois had not benefited southern Illinois as much as it had the rest of the state. The agricultural and forest land of the area was depleted, productivity was low, and economic conditions were poor.

To help correct this situation, a number of University staff members initiated a drive to start an experiment station in southern Illinois. Within a few years, through cooperative efforts by the people of the area, the U.S. Forest Service, and the University of Illinois, the Dixon Springs Experiment Station was established on approximately 5,000 acres in Pope County.

One of the most active persons in the campaign for the new experiment station was William G. Kammlade, then a member of the Animal Husbandry Department and later associate director of the Extension Service. Through the first 25 years of Dixon Springs' existence, he was closely associated with its work.

His reminiscences of those early years, "Sassafras and Persimmons," make up the major part of the book. Permeating his account are his enthusiasm for the new venture, a contagious interest in the rural life of southern Illinois, and a conviction that research, demonstrations, and extension teaching can provide people with the information they need to improve their lot.

How the Center grew out of the geographic, economic, and political conditions of the area is the subject of the first section of the book, written by Paul W. Rexroat, formerly publications editor in the College of Agriculture. H. A. Cate, communications specialist at the Center, concludes the book with an assessment of the Center's accomplishments. — *G. W. Salisbury*

(*Redeeming a Lost Heritage,* a 270-page, illustrated, soft-cover book, is available from the Publications Office, 123 Mumford Hall, Urbana, Illinois 61801, for $5. Make checks payable to the University of Illinois.)

Priscilla.

Sir Prize.

Introducing Two New Apple Varieties

With Scab Resistance and High Dessert Qualities

D. F. DAYTON and J. B. MOWRY

MANY EXCELLENT horticultural characters are combined with practical immunity to the apple scab disease in Priscilla and Sir Prize, new varieties resulting from cooperative research by the Agricultural Experiment Stations of Illinois, Purdue University (Indiana), and Rutgers University (New Jersey).

In addition, both have considerable resistance to apple mildew and fireblight. As a result, homeowners and commercial growers alike will find Priscilla and Sir Prize easier and less expensive to grow than most other varieties. Both new varieties are well adapted to the warm summers of the central Midwest. Trees of both are vigorous, bearing every year, and perform well as dwarf trees.

Apple scab resistance

Of all other apple varieties available in this country, only Prima shares Priscilla's and Sir Prize's resistance to apple scab. It, too, was developed by the Illinois, Indiana, and New Jersey Agricultural Experiment Stations (ILLINOIS RESEARCH, Winter, 1970).

Apple scab, caused by the fungus *Venturia inaequalis,* is highly destructive in most humid apple-producing areas of the world. Although good chemical control is possible, the disease is so insidious that it may cause severe loss of young fruit and foliage before it is recognized. Moreover, chemical control is expensive, exacting, and sometimes hazardous; and it consumes energy better used for other purposes. Indeed, even the raw materials from which the chemicals are manufactured are often basic energy sources. In Illinois at least five (and in some rainy springs several more) chemical sprays are necessary for adequate control.

The new varieties' very high resistance to apple scab is a dominant genetic character discovered in 1946 at the Illinois Agricultural Experiment Station. The character originally existed in *Malus floribunda,* an ornamental crabapple with ½-inch inedible fruit. Several generations of intensive and continuous effort over a 25-year period were necessary to combine this valuable character with the large fruit size and dessert qualities desired by consumers and essential for commercial production.

Priscilla

Priscilla is an early fall apple ripening September 10-15 at Urbana. It shows definite potential for commercial production as well as for home growing. The highly attractive, glossy red fruits approach 3 inches in diameter. The flesh is pale yellow with a good crisp texture, and a subacid, aromatic flavor. Dessert quality is rated as very good. The quality and good texture are retained in 34°F. storage for two months or more.

Like Sir Prize and Prima, Priscilla was developed by several generations of breeding over more than two decades, and thus has a complicated pedigree. Golden Delicious, McIn-

---

D. F. Dayton is professor of plant breeding; J. B. Mowry, professor of horticulture. The authors acknowledge the valuable contributions made by E. B. Williams, Jules Janick, and F. H. Emerson of Purdue University; and L. F. Hough and Catherine H. Bailey of Rutgers University.

tosh, and Starking Delicious all contributed to give Priscilla its own distinctive character.

As with most other apples, Priscilla requires cross pollination for good yields, but it produces copious amounts of viable pollen, making it a good pollinizer for other varieties, including Sir Prize and Prima. By planting Priscilla and Prima together for cross pollination, commercial producers can now grow large blocks of trees entirely free of any need for chemical control of apple scab, and with useful resistance to mildew and fireblight as a further advantage.

Sir Prize

Sir Prize is introduced as an easy-to-grow apple for home growing and possibly roadside marketing. The fruits are an attractive yellow, resembling Golden Delicious in shape and size, but with good resistance to shriveling from moisture loss, a serious fault with Golden Delicious.

Sir Prize is considered a "gourmet" apple because of its exceptionally high dessert quality. The flesh is pale yellow, fine-grained, and very tender, an advantage to persons with dental deficiencies. Its shriveling resistance allows it to store well in home refrigerators. However, the tender flesh and susceptibility to bruising make Sir Prize unsuited for present commercial systems of handling and packing.

Golden Delicious is one of Sir Prize's "grandparents," and a tetraploid form of Golden Delicious is the immediate seed parent, thus explaining the strong resemblance between the two varieties. Because of the tetraploid parent, Sir Prize has an unbalanced complement of chromosomes, which keeps it from producing viable pollen. However, most other apples growing nearby, including ornamental crabapples, should provide adequate pollination.

Availability

Trees of Priscilla are already available from several commercial nurseries, and Sir Prize trees will be available in limited quantities for spring, 1977, planting.

Mulching Proves Valuable For Dwarf Apple Trees

ROY K. SIMONS

FOR THE PAST 20 years or so, Illinois apple producers have been expressing a growing interest in dwarf trees — both those on dwarfing rootstocks and the spur types. This interest has been stimulated by consumer preferences, the labor shortage, high production costs, and the need for greater economic returns.

Most dwarfing rootstocks originated at the East Malling Research Station in England. When they were first planted in the United States, problems arose because of soil differences and the harsher climate.

In Illinois, the first commercial Malling (M.7) plantings date from 1956. The trees were low-budded, requiring staking. Trunk-twisting above the graft union area and burr knots have been common. Vertical growth cracks have appeared, and the scion tissue above the union has cracked as the result of sub-zero temperatures after a warm period.

Apples on dwarfing rootstocks and spur types were planted at the University of Illinois in 1963 to seek answers to some of the problems plaguing growers. As a result of experiments here and elsewhere, as well as growers' experience, East Malling stocks and spur types are being grown more successfully than with the limited knowledge of 20 years ago. Growers are now especially conscious of site and soil requirements.

Despite the progress made, improper cultural practices still result in less than optimum rootstock development. For example, allowing sprouts to grow adjacent to the graft-union keeps the trunk tissues from maturing and creates a situation conducive to winter injury. Conditions then become favorable for collar-rot development. Other problems are due to lack of proper care in planting and to inadequate soil care after planting.

Roy K. Simons is professor of pomology, Department of Horticulture.

Three mulches tried

One of the successful cultural practices tried in the University's planting of dwarf trees has been mulching. Trees with straw mulch have been compared to unmulched trees. Corn cobs, both whole and ground, have also been used.

In mulching dwarfing rootstocks, it is essential to keep the soil surface covered and to protect the shallow roots from extreme temperatures, both high and low. The soil covering should be a thin layer of continually decomposing material that will improve soil conditions for the root system. Mulch replenishment every two years seems to be adequate and, if a continual program is maintained, not too much should have to be applied at a time.

In our orchard, we clean out all debris around the trunk after harvest. With this practice, plus baiting, mouse damage has been prevented.

Yields on M.7 rootstock

Trees planted on M.7 rootstock in 1963 bore some fruit in the fourth

Table 1. — Average 1967-1975 Yields, Dwarf Trees Planted 1963

Variety/ rootstock	Cobs, whole	Cobs, ground	Straw mulch	No mulch
	pounds per tree			
Golden Delicious/M.7 . . .	249	256	253	219
Starking/M.7	210	225	233	172
Jonared/M.7	196	189	213	178

Table 2. — Average 1975 Yields, Dwarf Trees Planted 1963

Variety/ rootstock	Cobs, whole	Cobs, ground	Straw mulch	No mulch
	pounds per tree			
Golden Delicious/M.7	345	354	400	341
Starking/M.7	770	770	783	544
Jonared/M.7	514	403	565	498

Table 3. — Average 1975 Yields, Spur Types Planted 1963

Variety/ rootstock	Straw mulch	No mulch
	pounds per tree	
Red Spur/seedling	586	515
Red Spur/M.7	700	616
Red Spur/M.2	685	609
Miller 'Sturdee' Spur/M.7	736	681
Miller 'Sturdee' Spur/MM 106	968	865
Miller 'Sturdee' Spur/MM 104	547	679
Starkspur Golden Delicious/seedling	366	328
Golden Delicious/MM 106	575	424

year of growth and began to produce commercial yields during the fifth year. Since then, mulched trees have consistently outyielded unmulched trees (Table 1).

Fluctuations in yield have been more dependent upon winter and late spring freezes than any other single factor. For instance, on March 24-25, 1974, temperatures dropped from 80° to 26°F. after buds were in the green-tip stage or beyond. This freeze limited fruit production in the southern half of Illinois in 1974. Similarly, a frost on April 9-10, 1973, severely affected fruit set. Injury was prevalent on the fruit pedicel, and russeting was variable according to extremes in temperature fluctuations.

In 1975, adequate moisture and generally good growing conditions were conducive to optimum yields for the Red Delicious strains (Table 2). The response of Starking/M.7 to mulching that year was especially striking.

Spur types

Effects of mulching on several spur types of Red Delicious and one of Golden Delicious are shown for 1975 in Table 3. All except Millerspur/MM 104 responded well to mulching.

Mulching profitable

As shown by the 9-year yields, mulching can increase average yields by 30 to 60 pounds a year. Under these circumstances, it would be profitable to spend a small sum each year (25 to 50 cents a tree) for mulching materials.

Additional observations on dwarfing rootstocks

1. The M.7 rootstock responds to cultural treatments so readily that exercising the utmost care in cultural practices is economically feasible.

2. The M.7 rootstock has demonstrated that it induces earlier bearing and higher yields.

3. Use of the M.7 rootstock is economically valuable because it makes apple harvesting easier and permits pick-your-own plantings.

4. At first the various mulching treatments significantly affected the nutrient-element content of the leaves, but after 7 years' growth in the orchard, treatment was not the major influence on nutrient-element uptake. Cropping was the first factor to alter the uptake and time was the second factor.

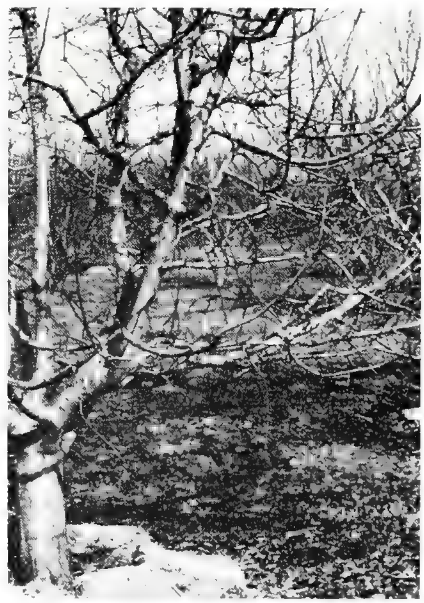
5. Tree size continues to be a problem on more fertile soils, particularly with Red Prince/MM 111 or 106. It has produced too much wood growth as the result of nonproduction of fruit. A spur type on MM 106 or MM 111 gives an excellent size of tree. Reasonably early cropping helps to control tree size.

6. Spur types on M.26, M.7, MM 111, and MM 106, established 6 years ago on a tight, heavy soil, began producing in the fifth year. These trees were not staked and continue to be free-standing. They were budded high and planting depth has maintained the graft union 2 inches above the soil level. The soil around the tree trunks was cultivated at least twice during the first growing season to make sure it would settle evenly. Since then, pea gravel has been used around the trunks of wind-whipped trees.

7. If a tree becomes loose and starts to wind-whip, the resulting damage is conducive to burr-knot formation. This problem, as well as that of sprouts on the trunk, can be reduced by the use of high-budded trees planted at a proper depth. Careful soil management during the first year's growth will also help prevent these difficulties.

8. Further studies are needed on root distribution of Malling rootstocks and their adaptability to various soils and climates.

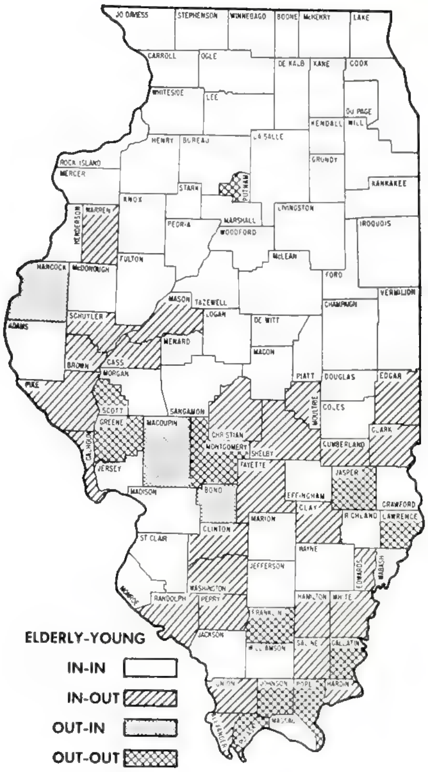
Mulched Red Spur/seedling, planted in 1963, blooming in 1970. (Fig. 1)



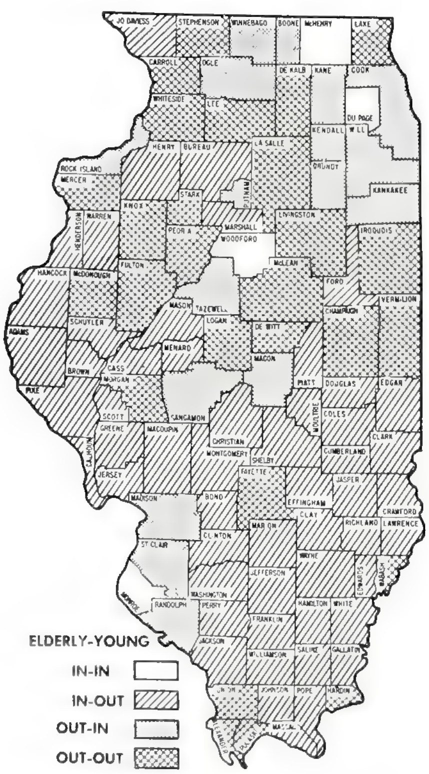
A February, 1975, picture of Golden Delicious/M.7, planted in 1963 and mulched with straw. (Fig. 2)

Migration and the Aging Of County Populations

J. C. VAN ES and MICHAEL BOWLING



Migration of the elderly and young in Illinois counties, 1950-1960. (Fig. 1)



Migration of the elderly and young in Illinois counties, 1960-1970. (Fig. 2)

THE POPULATION of Illinois is continuously changing. Between 1950 and 1970, for example, total population of the state increased by more than 2,400,000 persons. But not all counties shared equally in this growth. As is well known, much of the population growth between 1950 and 1970 was concentrated in urban areas, while many of the rural areas lost population.

To determine the impact of the population redistribution, it is useful to look at two "strategic" age groups — the young and the elderly. The migration of these two groups is especially important because it is often the direct result of local circumstances, particularly economic ones, and in turn has important long-term effects on local conditions.

Why people move

Both the young and the elderly in any community have to make decisions about where to spend their future years. For the young, a major consideration is the economic opportunities offered in the local area. If there are greater opportunities in other areas, the young may need to migrate to those places.

The elderly, while in general less mobile than the young, may need to make a migration decision when they retire. Their retirement income may not be enough to maintain their way of life in their present residence and they may look for less expensive places to live. At the same time, the discontinuation of work gives the elderly a chance to seek a more desirable environment than the one they have been living in. Climate, personal safety, and proximity to friends and relatives, as well as less expensive living conditions, often motivate the elderly to move.

J. C. van Es is an associate professor and Michael Bowling a research assistant in rural sociology. Data are from the U.S. Census and were gathered through ISEIRD (Illinois Social and Economic Indicators for Rural Development).

Potential effects

Local communities are, of course, concerned about the effects of migration upon their populations. Marked shifts in the composition of the population are of particular importance to officials making decisions about such local services as health care, public assistance, and education.

If a community lacks the economic opportunities to hold or attract young people, then a vital and energetic part of its population will be lost, while areas with economic opportunities will receive a larger share of the young. A community that is losing its young people may be concerned about the proportion of its population that is elderly, especially if older people are moving into the community as young people leave.

Scope of study

To learn more about migration patterns in the state, we determined migration rates of the young and of the elderly for each county during two decades — 1950-1960 and 1960-1970. The young were defined as those aged 15-19 at the beginning of a decade and 25-29 at the end. The elderly were defined as 60-64 at the beginning of the decade and 70-74 at the end. These age ranges were chosen as representing the times

when people are most likely to make decisions about moving.

Migration rates were expressed as the percentages of a county's population in the various age groups, and were calculated by use of the census-survival forward method. In discussing the results in this paper, we will use the terms "in-migration" and "out-migration" to reflect the net balance of people moving into and out of a county.

State trends

A marked difference showed up between the 1950's and the 1960's in the migration patterns of the state's 102 counties (Table 1).

During the earlier decade, the young and the elderly migrated in the same direction in 74 counties. Both groups were migrating into 62 counties, and both groups were migrating from 12 counties. (The rates of migration were quite different, however, with the young usually migrating in larger proportions.)

Figure 1 illustrates the 1950-1960 migration pattern for each county and for the state as a whole. During this period counties in the northern half of the state received an influx of both the young and the elderly. In the southern half of the state the migration patterns were much more complex.

A remarkable reversal occurred in the 1960's. By then the elderly and the young were migrating in opposite directions in 71 counties. In 54 counties, the young were out-migrating while the elderly were in-migrating. At the same time the young were moving into 17 counties that the elderly were leaving.

Comparing Figures 1 and 2 clearly demonstrates the differences in migration patterns between the two decades. While in the 1950's the northern counties had an overwhelming in-migration of both the young and the elderly, many of these counties registered out-migration for both age groups during the 1960's, and other counties registered out-migration of the elderly. Southern counties generally experienced out-migration of the young, while most of them experienced in-migration of the elderly.

Metropolitan vs. nonmetropolitan

Between 1950 and 1970, population grew especially fast in and around the larger cities of the state. It may therefore be useful to compare the migration patterns of the metropolitan and nonmetropolitan counties.

Designation as an SMSA (Standard Metropolitan Statistical Area) by the U.S. Bureau of the Census is an indication of a county's metropolitan character. There were 13 SMSA counties in Illinois during the 1950's (Cook, DuPage, Kane, Lake, Macon, Madison, Peoria, Rock Island, St. Clair, Sangamon, Tazewell, Will, Winnebago) and 15 such counties during the 1960's (the preceding counties plus Champaign and McHenry).

Table 2 illustrates the migration patterns of metropolitan and nonmetropolitan counties for the two decades. During the 1950's in-migration of both the young and the elderly predominated in most of the nonmetropolitan counties, and was the only pattern of migration in the 13 metropolitan counties.

By the 1960's, the predominant pattern had radically changed. Of the nonmetropolitan counties, 54, or 60 percent, had a net in-migration of the elderly combined with out-migration of the young. As for the 15 metropolitan counties, 10 were now experiencing out-migration of the elderly and in-migration of the young.

Will trends remain the same?

As we have seen, the migration patterns of both the young and the elderly, but especially the elderly, have undergone important changes in Illinois between the 1950's and the 1960's. Of particular significance for nonmetropolitan counties is the fact that twice as many of these counties lost young people and gained elderly people during the second decade as during the first one.

Migration to and from other states may have accounted for at least some of the population changes. One cannot infer from the data that either the young or the old were moving from one county to another in Illinois.

The hazard of trying to anticipate future migration trends is indicated by the great changes between the 1950's and the 1960's. A further complication is the growth of the nonmetropolitan population that has been noted since 1970 in some states, although this trend has not yet become strong in Illinois.

Nevertheless, the data suggest that many Illinois counties may acquire more rapidly aging populations both because young people are leaving and because older people are moving in. If these trends do persist, many counties will have to reassess their investments in services to reflect the needs of their changing populations.

Table 1. — Migration Patterns of the Elderly and Young in Illinois Counties

Elderly	Young: In-migration	Young: Out-migration
1950-1960		
	No. of counties	
In-migration	62	25
Out-migration	3	12
1960-1970		
In-migration	4	54
Out-migration	17	27

Table 2. — Migration of the Elderly and the Young in Metropolitan and Nonmetropolitan Counties

Type of county	Migration: In-in[a]	In-out	Out-in	Out-out
1950-1960				
	No. of counties			
Nonmetropolitan	49	25	3	12
Metropolitan	13	0	0	0
1960-1970				
Nonmetropolitan	2	54	7	24
Metropolitan	2	0	10	3

[a] Migration of the elderly is mentioned first; that of the young second.

Dietary Patterns of the Elderly

ESTHER L. BROWN and SHARON M. HOERR

Many of the 25 million Americans who are 65 or older do not eat well. Several reasons have been suggested for their poor nutrition — reduced income, limited access to the food supply, loneliness, inadequate or inaccurate knowledge of nutrition.

More needs to be known about physical, mental, social, and economic factors influencing the diet adequacy and food choices of the elderly. A study of the subject was therefore undertaken in the School of Human Resources and Family Studies.

People in study

A stratified sample of 303 elderly people in Champaign-Urbana was randomly selected from the retiree list of the University of Illinois (46 percent of the individuals) and from the rolls of the Homestead Exemption Act (54 percent). Individuals were all 65 years of age or over, and were non-institutionalized.

The sample was predominantly female (74 percent), white, of northern European ancestry, middle-class, Protestant, and fairly active physically and socially. Most had been brought up in small to medium-sized towns. The age range was: 65-69 years of age, 23 percent; 70-74, 36 percent; 75-79, 25 percent; 80 and over, 16 percent. Most (63 percent) had some college background; 27 percent had completed more than four years of college. Nearly two-thirds were living with a spouse, relative, or housemate.

Information obtained

Interviews were conducted to determine diet adequacy; the relationship between diet adequacy and selected family characteristics; attitudes and knowledge which affect food choices; and possible focus of nutrition education.

The respondents' nutrition knowledge was checked by asking them to express agreement or disagreement with several statements about nutrition. They were also asked to study a list of foods or food groups and to check the ones usually eaten, how often, and approximate amounts (frequency recall method).

The information obtained by the frequency recall method was analyzed by the Leichsenring Short Method of Dietary Analysis to calculate intakes of calories and of eight nutrients: protein, calcium, iron, vitamins A and C, thiamin, riboflavin, and niacin. Mean intake levels were then compared to the Recommended Dietary Allowances (1974 Eighth Revised Edition). An individual's intake of each nutrient was rated according to the following criteria:

Rating	*Pct. of RDA*
Poor	Less than 50
Fair	50-67
Good	67-100
Excellent	100 or more

The lowest mean nutrient intake in a respondent's diet determined his overall dietary intake rating. For example, if a person's nutrient intakes were all "good" except for a "fair" rating for iron, the overall dietary rating was designated "fair."

General food habits

Almost two-thirds of the respondents had changed their diets within the past five years. About half of the changes had been for health reasons and the rest were due to changes in life style. Most of the changes resulted in a smaller food intake, a restriction of the diet, or a change in cooking patterns.

At the time of the study, 43 percent had some type of diet restriction. The most common, in descending order, were low-roughage, low-carbohydrate, and low-fat diets. About half took vitamin-mineral supplements, but less than half of these supplements were prescribed by a physician.

Only 4 percent mentioned their diet restriction as a reason for their choice of foods. Half of the group said they consumed their foods for taste and enjoyment; 26 percent, for good nutrition and energy; 8 percent, out of habit; and another 8 percent, to keep from starving.

Most of the group shopped two or three times a week at supermarkets. The majority (86 percent) said they were guided by meal plans. Nearly half never read food labels in detail. Fresh foods tended to be chosen most often; dry foods, least often.

Many of the respondents (44 percent) ate at least one meal a day alone; 63 percent ate one to three meals a week away from home.

Food intake

About 58 percent of the group had "good" or "excellent" dietary intakes (Table 1). However, 83 percent rated their intake as good or better, and 87 percent believed that they did not need to modify their food intake. Unfortunately there was no correlation between the ratings people gave themselves and the ratings they actually received. However, the better the intake was self-rated, the more likely a meal guide was used.

There were no statistically significant correlations between either sex or age and the quality of the diet. However, the incidence of excellent food intake tended to increase with age and to be higher for men than for women.

In all age groups, the percentage of men eating excellent diets equaled or surpassed the percentage of women eating this well, although the women outnumbered the men almost three to one. Six of the eight men

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Table 1. — Summary, Dietary Intake Ratings

Sex	Rating			
	Excellent	Good	Fair	Poor
	percent			
Men	10.1	45.6	30.4	13.9
Women	9.8	51.3	26.8	12.1
Aver.	10.0	48.4	28.6	13.0

with excellent intakes were living with someone. However, there was no correlation between diet adequacy and the number in the household.

People over 80 had a higher percentage of excellent food intakes than did any other age group. This suggests a possible relationship between good food habits and a long, active life (none of the respondents were in a nursing or retirement home). The younger the group, the higher the percentage of intakes that were less than good.

Intakes of the eight nutrients were high overall. This was especially true for protein, vitamin A, vitamin C, and riboflavin. The percentages of people consuming more than 100 percent of the RDAs for these nutrients ranged from 73 to 97. Niacin and calcium were the two most poorly consumed nutrients, with 15 percent of the respondents having less than good intakes. For iron, 7 percent had less than good intakes; and for thiamin, 11 percent. Although men and women did not differ significantly in the ratings for each nutrient, individuals with fair and poor intakes tended to be women under 80.

A low or marginal calorie intake is what lowered the overall rating most often. The intake rating was less than good for 23 percent of the respondents.

Two factors may have affected this result: One is that individuals who believe their calorie intake is too high tend to underestimate their consumption. The other is that the RDAs used to analyze diet quality were for persons 51 years of age and over — the oldest age group included in the 1974 edition. As caloric requirements decrease with age, it is possible that the respondents, aged 65 to 93, had somewhat lower requirements.

Food choices

"Food choices" include what people choose to eat, their reasons for their choices, and eating patterns. Several interacting factors influence food choices, including income, culture, concern about one's health, socialization, and religion.

In this study, it was found that fresh foods were eaten most often by respondents with the highest incomes. Frozen food use increased with increasing educational level and with decreasing age. Use of dried foods increased as respondents spent more money on groceries.

Diet adequacy was negatively correlated with the use of a meal guide — the better the food intake, the *less* a guide tended to be used or was claimed to be used. The only other factor correlating with diet adequacy was whether the respondent was a University retiree or a Homestead Exemption participant (University retirees having better diets).

Meal patterns were associated with several factors. An increase in number of meals eaten alone was associated with increased age, fewer persons in the household, decreased family income and grocery cost, and an increased likelihood that the respondent was a woman.

Meals eaten with children and other relatives increased with decreasing education and income. Also, respondents who had grown up in small towns and rural areas tended to eat more meals with children than did those with an urban background. Meals eaten with people other than relatives increased with increasing income, education, and number of meals eaten away from home. More meals were eaten away from home by the younger respondents, who were also more likely to be employed and to have a higher educational level and higher income.

Attitudes and knowledge

Diet adequacy was significantly associated with only two items of the nutrition knowledge test. Ratings tended to improve as respondents agreed with these two statements:

"People who eat dark green and dark yellow vegetables will probably be consuming sufficient vitamin A."

"Breads, cereals, and flour are enriched with thiamin, riboflavin, niacin, and iron."

Although educational level and age did not correlate with diet adequacy, the better educated gave more right answers to the knowledge test. The number of right answers declined with increasing age.

Women tended to do better on the nutrition knowledge test and to be more willing than men to take individual initiative and responsibility for good nutrition. However, the more the respondent's food habits tended to be female-role-dominated, the less adequate the vitamin C intake and the less flexible the person was in food choices and habits.

A high score on the nutrition knowledge test was positively associated with flexibility, individual initiative and responsibility in food choices, and a favorable attitude toward government control of foods and nutrition.

Forty-eight percent of the sample took vitamin-mineral supplements. Although the supplement intake did not affect overall diet adequacy, it was positively associated with good niacin intake. Interestingly, the vitamin-mineral takers favored government control of foods and nutrition, but did not regard medical professionals very highly as sources of nutrition information.

Trends shown

Although the findings did not show significant relationships between diet adequacy and income, education, age, religion, and culture, the trends were there. It must be remembered that the sample was a rather homogeneous population of upper-lower to middle class citizens in the Midwest. The study has shown that many elderly people are interested in nutrition, and the results pinpoint some needed areas of nutrition education.

Sludge In the Pasture?

Applying sludge to strip-mined soils has provided good pasture without a detectable build-up of disease agents

WILLIAM R. JOLLEY and PAUL R. FITZGERALD

IDEALLY human, animal, and industrial wastes are treated to reduce offensive odors, disease organisms, and toxicity before being disposed of or in some way recycled. Unfortunately, the diverse nature of the wastes, especially those generated by large urban complexes, has made effective treatment difficult. Recent social and legislative pressure has prompted research not only to solve the problems of sewage disposal, but also to find ways of utilizing the waste material.

The Illinois Agricultural Experiment Station has undertaken several research projects on this subject. One, carried on in cooperation with the Metropolitan Sanitary District of Greater Chicago, is aimed at determining whether anaerobically digested sewage sludge can convert infertile strip-mined land into productive pastures without increasing the risk of disease or toxicity.

For more than two years, sludge has been applied to a 400-acre experimental pasture on strip-mined land in Fulton County. Several miles away, a 200-acre control pasture is located on land that has never been strip-mined and has never received sludge. Sudax grass is grown on both pastures, and both are grazed by beef cattle.

Although the strip-mine pasture is a small part of the overall agricultural reclamation effort in Fulton County, it represents one kind of the food web models now being tested. The three major components being exposed to the sludge are soil, vegetation, and cattle.

William R. Jolley is a former research associate; Paul R. Fitzgerald is professor of veterinary research and parasitology.

Sludge characteristics

The sludge is produced in anaerobic digesters which operate in the mesophilic temperature range (29° to 38°C.). As concentrated sludge is fed into the digesters, it is acted upon by a combination of anaerobic bacteria. This action converts 40 to 50 percent of the organic solids into methane, carbon dioxide, and other gases. The digested (stabilized) sludge contains many substances, including nitrates, nitrites, ammonia, heavy metals, and other trace elements and chemical residues, the amounts varying with the source of the sludge.

Digested sludge is a black liquid containing 1 to 5 percent solids. It is slightly acid to slightly alkaline (pH 6.5 to 8.0). The odor is generally mild and inoffensive, resembling that of crude petroleum.

Soil analysis

Samples of soil are collected regularly from specific locations in the sludge-sprinkled and the control pastures. They are analyzed by atomic absorption for the heavy metals cadmium, chromium, copper, manganese, mercury, nickel, lead, and zinc (Table 1). Soil concentrations of these metals were about the same in both pastures during the first two years of testing.

Vegetation analysis

Sudax grass, an annual sorghum-sudan grass hybrid, was chosen for use because of its quick assimilation of nutrients from soil and its rapid growth. Regular samples of the sudax were analyzed for nutrients, heavy metals, and polychlorinated biphenyls (which comprise some of the plastics).

Table 1. — Average Amounts of Eight Elements in Soils From Sludge-Irrigated and Unirrigated Pastures

Element	Irrigated pasture	Un-irrigated pasture
	ppm	ppm
Cadmium	1	1
Chromium	22	12
Copper	18	18
Manganese	585	585
Mercury[a]	128	116
Nickel	35	46
Lead	16	20
Zinc	75	111

[a] Parts per billion.

Analyses were run for nutritional and toxic substances: protein, fiber, calcium, phosphorus, potassium nitrate, cyanide, arsenic, sodium, potassium, zinc, magnesium, and iron (Table 2). According to the best available criteria, the irrigated sudax was nutritonally adequate and was at least as good as sudax grown in the control pasture.

Further analyses were made for chromium, copper, lead, nickel, and manganese to determine whether the plants were assimilating and accumulating these metals to toxic levels. So far no toxic buildup has been observed.

Polychlorinated biphenyls (PCB) ranged from 0.1 to 1.2 micrograms per gram in sludge-irrigated sudax and from 0.2 to 0.4 microgram per

Behind the fence ungrazed sudax grass grows on strip-mined land irrigated with sludge.

Table 2. — Average Amounts of Some Elements and Other Substances, Both Nutritional and Toxic, In Vegetation From Sludge-Irrigated and Unirrigated Pastures

Substance	Irrigated pasture	Un-irrigated pasture
Calcium, ppm	4,468	7,640
Chromium, ppm	12	11
Copper, ppm	13	11
Iron, ppm	973	4,962
Magnesium, ppb[a]	4,536	3,721
Manganese, ppm	53	139
Sodium, ppm	309	478
Nickel, ppm	7	11
Lead, ppm	7	10
Phosphorus, ppm	3,400	1,700
Potassium, ppb[a]	17	38
Zinc, ppm	61	81
Protein, pct.	15	15
Fiber, pct.	24	35
Nitrates, pct.[b]	1	1
Arsenic, ppm	0	0
Cyanide, ppm	0	0
Polychlorinated biphenyls, ppm	0.4	0.32

[a] Parts per billion.
[b] Analyzed as potassium nitrate.

gram in sudax from control pastures. To our knowledge, no standards have been established for acceptable levels of PCB in animal forages.

Parasitology

The types and relative numbers of coccidian and helminth parasites in the two cattle herds were monitored and compared to detect any which may have been present in the sludge. No appreciable differences have as yet been observed in the two herds.

Sludge may affect parasite loads more by its effects on exogenous (outside the host) stages of normal bovine parasites than by its introduction of eggs or oocysts to pastures. The indigenous protozoan and helminth parasites are regularly expelled from the host into the pasture environment for a period of time, during which the eggs, oocysts, or larvae must withstand adverse conditions to survive. The effect of sludge on such organisms under these conditions is relatively unknown.

Some parasites are resistant to anaerobic digestion. In preliminary tests, coccidia oocysts, ova of the large roundworm of pigs, and larvae of stomach worms were incubated in digesting sludge at 10°, 22°, or 39°C. to determine the effect on the survival of these stages. The sludge was detrimental to the oocysts, especially at the higher temperatures; slightly detrimental to stomach worm ova; and lethal to the first- and second-stage nematode larvae. It killed some but not all of the ensheathed third-stage larvae. Ova of the large roundworm of swine were resistant. Sludge appeared to encourage migration of the third-stage larvae into the grass more than did water applied in the laboratory under similar conditions.

So far no unusual clinical signs due to bacterial or viral infections have been observed in animals of either herd. Unlike many of the protozoan and helminth parasites, most pathogenic bacteria and viruses are destroyed by the anaerobic digestion process. Surveillance of animals for evidence of disease caused by these organisms is continuing.

Further research

Results thus far must be cautiously interpreted and should be considered of preliminary value. More extensive studies are being conducted.

In one current study, tissues from cattle are being analyzed for heavy metals and PCB. Another unanswered question is whether the cattle are directly ingesting sludge-bound ingredients. Although the animals have not been seen ingesting sludge from the surface of plants or the ground, uptake of some surface film on the herbage is unavoidable, and other direct means of intake are possible.

Some results of the preliminary studies are seemingly contradictory. For example, if the sludge is detrimental to the oocysts, ova, and larvae tested in the laboratory, would not the parasites eventually die out, or be eliminated from the pasture environment? The conditions in the laboratory are limited in that only one variable, such as temperature or pH, is introduced at a time. In the pasture environment, a multitude of changing conditions exists — air and soil temperatures, humidity, precipitation, solar radiation, vegetative cover, to name a few. While laboratory studies may indicate a cause or effect, definitive answers must come from the sludge-irrigated pastures where realistic conditions exist.

Up to now, sludge applications to pastures have not caused any detectable buildup of bovine disease agents. As application levels increase, the likelihood of accumulation may become greater; hence pasture food web components should continue to be monitored for as long as possible.

Lead Concentrations in an Ecosystem Including Rural and Urban Areas

KETURAH A. REINBOLD and GARY L. ROLFE

EACH YEAR thousands of tons of lead are released into the environment in the United States. Where does it go and what are the effects? Interdisciplinary research teams at the University of Illinois are seeking answers to these questions. Knowing the rate at which lead enters the environment, its concentration, and its movement in air, soil, water, plants, and animals is of basic importance in evaluating the potential hazards of lead contamination.

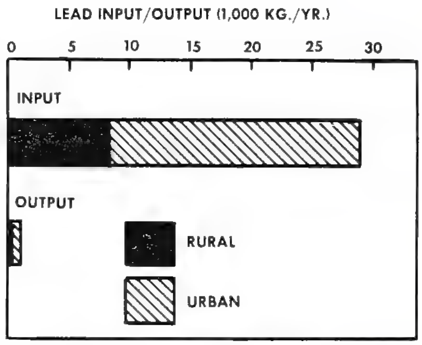
One research team recently completed an analysis of lead in an 86-square-mile ecosystem based on a watershed area in east-central Illinois. The watershed is primarily a rural, agricultural area north of Champaign. However, it also includes about 90 percent of the cities of Champaign and Urbana, which have a combined population of about 100,000.

Inputs and outputs

To determine the potential amount of lead accumulation in the watershed system, an input-output analysis was started early in the study. Combustion of gasoline is the major source of lead input into the area. To calculate the amount of gasoline consumed, we computed traffic volumes for different types of roads and combined them with gasoline consumption rates at various driving speeds. A total of 56,575 gallons is consumed per day, over 80 percent of it in the urban area.

On the basis of gasoline consumption, the amount of lead in gasoline, and lead emission rates under various driving conditions, the calculated yearly input of lead to the watershed is 29,000 kilograms (32 tons). About 65 percent of this total is emitted in the 12-square-mile urban part of the watershed.

Keturah A. Reinbold is assistant director, Metals Task Force, Institute for Environmental Studies; Gary L. Rolfe, associate professor of forestry and environmental studies and director, Metals Task Force.



Lead input vs. output in urban and rural parts of watershed area. (Fig. 1)

Of the total lead input, 46 percent remains airborne. This leaves approximately 16,000 kg. (17.5 tons) that is immediately deposited at ground level, mostly in the cities and along major highways in the rural area. An additional 800 kg. (0.9 ton) per year of the airborne lead is washed out and deposited on the ground by rainfall.

Once the amount of lead entering the ecosystem was known, we had to determine the amount leaving the area so that the remaining amount could be calculated. The major exit route of lead is through drainage waters. Although some lead is dissolved in the water, about 80 percent of it is carried by suspended solids. The amount of suspended lead is greater in the urban area because there one finds large areas of impervious surfaces, such as pavement and roofs, from which particles are washed by rain into drainage water. Using stream samples adjusted for storm periods, we estimated that 910 kg. (1 ton) of lead per year leaves the ecosystem in stream water. About 75 percent of this amount comes from the urban area.

As Figure 1 illustrates, there is a striking difference between the lead input and output in the watershed area. With a deposition rate of over 16,000 kg. (17.5 tons) per year, the output is only 5.7 percent of the input. Thus, most of the lead accumulates in various components of the system, especially in the urban area and along major highways.

Lead distribution

Various components of the ecosystem, including air, water, soil, plants, and animals, were sampled and analyzed to determine where the lead accumulates. As would be expected, the highest levels of lead in each component were found in the urban area and along heavily traveled roads in the rural region.

Air concentrations of lead were low in the rural area (0.19 microgram per square meter), but in the urban area varied from 1.35 micrograms per square meter on heavily traveled downtown streets to 0.29 microgram on quiet residential streets.

Soil concentrations of lead were measured in vertical profiles as deep as 80 centimeters (32 inches) and also in line transects extending several hundred meters from roads and highways of various traffic volumes.

Highest concentrations were found in the upper 10 centimeters (4 inches) of soil next to streets and roads carrying heavy traffic. Considerably higher concentrations oc-

curred in urban than in rural profiles, indicating a strong correlation with traffic volume. Typical lead concentrations in the upper 10 cm. (4 inches) are 390 parts per million (ppm) near a city street and 16 ppm in an agricultural field remote from any highway.

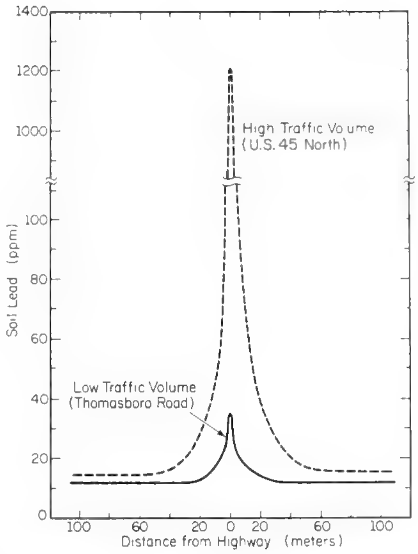
Results of soil lead measurements along transects indicate that the higher the traffic volume, the higher the soil's lead content and the farther these elevated lead concentrations extend from the highway (Fig. 2). Prevailing winds influence the extent of high soil lead levels along north-south highways. Even on the most heavily traveled roads, however, the high levels extend only 50 meters (160 feet) downwind (east) and 25 meters (80 feet) upwind.

Along east-west roads with high traffic volumes, lead concentrations drop to background levels within 30 meters (100 feet) on either side of the pavement. Along lightly traveled roads, lead levels decrease to background levels within 20 meters (65 feet) from the pavement. Extremely high soil lead levels (about 750 ppm) seldom extend beyond the right-of-way of rural roads.

Vegetation samples were also taken along transects at varying distances from roads. The relationship between lead content and distance from the road was similar to that observed for soils. Again the highest concentrations occurred in the urban area and near heavily traveled rural roads.

Within 20 meters (65 feet) of the busiest roads, corn and soybean plants contained about 30 ppm of lead, significantly more than the average for the field (8 ppm). Beyond 30 meters (100 feet), however, there was no difference from the average. On roads with lighter traffic, no influence on crop lead concentrations was observed. Analyses of grain from corn and soybeans showed consistently low lead contents, averaging less than 2 ppm.

In the urban area, plant lead concentrations were highest near high-use streets and gradually decreased with increasing distance from the



Soil lead in relationship to distance from highway. **(Fig. 2)**

pavement of both heavily and lightly traveled streets.

Even though concentrations in individual plants were not high, the total weight of vegetation in the watershed was so large that it is estimated to hold 2,200 kg. (2.5 tons) of lead.

Animals. Lead concentrations in animals (small mammals, birds, reptiles, and amphibians) were also highest next to high-use roads and in the cities. For all animals, however, total body lead concentrations were relatively low. Lead was not concentrated in any of the vital organs, with the possible exception of the liver and kidneys.

It was established that at any given time, 23.7 grams (0.05 pound) of lead is contained within the bodies of the small mammal population of the watershed. This amount is so small that it is an insignificant factor in the movement of lead through the ecosystem. Thus, it is doubtful that the lead in animals affects their populations.

Insects. In insects, the highest lead concentrations (24.7 ppm) were found next to heavily traveled roads. Concentrations increase as one moves up the insect food chain, the amount of increase depending on feeding method. In high-lead areas, concentrations increase from insects that suck plant juices, to species that chew plant parts, to those that prey on other insects. Thus, for predaceous insects, lead appears to be concentrated through the food chain.

Lead may also be concentrated through the food chain in shrews. Those that feed on insects show higher concentrations than those that don't. In other vertebrates there was no evidence that lead is concentrated through food chains.

Water. In the area's streams, lead was concentrated in the upper 10 centimeters of sediment, a finding similar to that for soil. Concentrations were many times higher in urban stream sediments (387.5 ppm) than in rural ones. These high urban levels are due to the quantity of lead particles washed from extensive impervious surfaces during storms.

Aquatic organisms in the urban area contained lead concentrations 10 to 20 times higher than those from the rural area. No biological magnification of lead through aquatic food chains was found anywhere.

Implications of study

This study clearly shows that most of the lead entering the watershed stays there. The major storage places for lead are soils (over 900,000 kg.), plants (over 2,000 kg.), and stream sediments (over 3,000 kg.).

Present concentrations of lead do not appear to offer a serious problem. However, agricultural crops along major highways and all urban vegetation are in a chronic lead insult zone. These areas should be monitored in the future to determine if lead concentrations become toxic with time and with additional lead input.

Effects of soil characteristics on vegetative lead content must be considered. Soils in the area studied have a strong binding capacity for lead, making less lead available for uptake by plants. Lighter soils, particularly sandy ones, typically have lower lead-binding capacities, and plants may thus be adversely affected at relatively low soil lead concentrations. These points are now being studied.

100 Years of Dairy Science At the University of Illinois

THE CENTENNIAL of Agricultural Experiment Stations in the United States has given us an incentive to review the history and major research accomplishments in dairy science at the University of Illinois over the past 100 years.

In 1870, just three years after the University was founded, research began on milk composition and milk production. However, no staff member was specifically assigned to dairying until 1896, when William J. Fraser was appointed the first instructor in this field.

In 1902 the Department of Dairy Husbandry was established with three faculty members. Today the Department of Dairy Science, as it is now called, encompasses nearly 100 academic and nonacademic personnel. They conduct laboratory research and operate a 400-acre research dairy farm with over 600 animals. The department includes the Divisions of Biochemistry, Genetics, Management, Microbiology, Nutrition, Physiology, and Extension.

Over the years, research in dairy science has been highly diversified. Significant contributions range from practical applications to basic knowledge, as indicated by the following brief review of some of the major accomplishments.

Research in dairy management

Professor Fraser was often ahead of his time, as when he pointed out the value of using high-yielding crops for forage and stressed the relationship of high production per cow to the dairyman's income. He also helped to start the first Cow Testing Association in Illinois in the early 1900's. ("Cow Testing Association" designated the national dairy production program until 1927, when "Dairy Herd Improvement Association," coined in the department as being more descriptive, was officially adopted nationwide.)

The Weigh-A-Day-A-Month plan, begun in Clinton County, Illinois, in 1953, is now part of the national Dairy Herd Improvement Program. The plan calls for the dairyman to weigh the milk from each cow one day every month. Production for individual cows and for the herd are then computed. This is an economical way of improving herd efficiency.

A formula for fat corrected milk, devised in the early 1920's, has been widely used in the dairy industry to compare the energy value of milk with different fat percentages. Dating from that same period is a method for estimating the money value of corn silage harvested at varying stages of maturity and moisture content. This method, probably still the best for its purpose, has been extensively used in recent years to estimate the value of frost- and drouth-damaged corn.

One of the earliest impacts of the department on the Illinois dairy industry was the appearance of round barns throughout the state, some of which are still standing. Detailed plans and advantages for this type of structure were set forth in several publications between 1905 and 1920.

Much of our knowledge about feeding and managing calves evolved from departmental studies on such topics as the inclusion of roughage in the calf's diet, the composition of calf starters, milk replacers, and the early weaning of calves. The department's specialists in milk processing conducted some of the crucial research that led to the now common procedures of clean-in-place pipelines, use of a high temperature and a short time for milk pasteurization, and the use of paper milk cartons.

The inadequacy of self-feeding dairy cows was discovered in 1927. It was found that, if cows are allowed to choose their own feed, they will eat more high-priced concentrates than they need, except for a short time after calving. Further, cows differ markedly from one another, and from one feeding time to the next, in their feed selection.

This research was the forerunner of several recent approaches to automated feeding. An electronic feeder has been developed which can be adjusted to feed grain automatically to individual cows according to signals from a transponder system. The department was a pioneer in developing mechanical feed delivery systems and in testing management systems for the automatic mixing of concentrates and forages into one blended feed. Grouping cows by daily production has now evolved as a way to alleviate the problems of free choice feeding.

Through the years, outstanding animals have been developed in the department's herd. The most famous was Illini Nellie, who in 1935 set a world's record for milk fat in the Brown Swiss breed and was also Reserve Grand Champion at the National Dairy Show in 1935.

Dairy genetics

In the early 1920's, great interest was shown in dairy cattle evaluation. The bull's contribution to inheritance was difficult to evaluate because he could be tested only through the performance of his daughters. In 1924

This article is based on papers presented at a special seminar commemorating the centennial of Agricultural Experiment Stations in the United States. Contributions to the seminar were made by J. L. Robinson, L. R. Fryman, S. L. Spahr, M. Grossman, J. R. Lodge, M. P. Bryant, C. L. Davis, and K. E. Harshbarger.

In 1935 Illini Nellie set a world's record for milk fat in the Brown Swiss Breed that stood for 10 years — 29,569.5 pounds of milk and 1,200 pounds of butterfat.

department members developed an evaluation index based on the equal contribution of the sire and dam to a daughter's productivity. The bull's value as a sire could then be predicted after his first few daughters were tested. Sire evaluation is still based on this principle, more than 50 years after it was first formulated.

The department has been at the forefront of studies on the inheritance of milk yield, milk composition, and other traits. Crossbreeding Guernseys and Holsteins was particularly successful in assessing the mode of inheritance of particular traits. It also showed that yield traits of crossbred progeny did not exceed those of purebred Holstein progeny.

Reproductive physiology

One of the department's early studies concerned sperm transport in the female reproductive tract. Spermatozoa were found at the site of fertilization within 5 minutes after being deposited in the tract either naturally or by artificial insemination.

Much research on the morphology, physiology, and biochemistry of spermatozoa has been conducted through the years. The Illini Variable Temperature Extender for preserving spermatozoa at room temperature was developed in the 1950's. It maintains higher fertility than do most of the commonly used extenders for low-temperature liquid storage. Other studies have concerned the effects of storage time and temperatures on sperm fertility and on embryonic mortality.

Rumen function

Dairy cattle depend on a very complex mixture of microbes in the rumen to digest their feed. Accordingly, the department has conducted research on the metabolism of rumen bacteria and has pioneered the use of radioactive isotopes to measure the utilization and production of components in the rumen and the whole animal.

Type and reference strains of the major rumen and methanogenic bacterial species are maintained in a culture collection and are made available to scientists around the world. Recent research concerns the theory of microbial fermentation balance and its application to the rumen. Researchers have perfected a continuous-flow artificial rumen system to model overall reactions of the rumen.

As the result of further studies, the importance of hydrogen as an intermediate in methanogenic fermentations has been recognized, and the pathways of anaerobic degradation have been elucidated. The discovery that hydrogen is transferred from one bacterial species to another has greatly increased our understanding of factors affecting proportions of fermentation products in the rumen. Much of this research is relevant to animal waste treatment systems as well as rumen function.

Mammary gland function

Around 1915, experiments were conducted to differentiate between synthesis and ejection of milk. All of the milk removed by milking was found to have been stored in the mammary gland. It was also shown that the hormone oxytocin caused milk letdown and enabled the milker to obtain extra or residual milk with an unusually high fat test.

Another early study on mammary gland function established the composition of milk and the effects of breed and stage of lactation on milk composition. The major milk solids are lactose (milk sugar), protein, and fat.

Further research efforts helped show the pathways of biosynthesis and excretion of these components. Some of the first research to demonstrate the enzymatic steps in the synthesis of lactose was conducted in this department. The research contributed much toward our understanding of galactosemia (an inherited inability to metabolize lactose) in man and animals.

Until the 1950's, much confusion existed on the origin of major milk proteins, but departmental researchers showed clearly that over 90 percent of the milk protein is synthesized in the mammary gland. The specific amino acids needed by the mammary gland were established, utilizing the first culture of lactating mammary tissue cells. Using radioisotope tracer techniques, staff in the department have established pool sizes and turnover rates of many key metabolites and precursor-product relationships as they affect the formation of major milk components.

A continuing effort

The accomplishments of the Department of Dairy Science were made possible through the creativity and diligence of many people. As a result of research both here and elsewhere, dairy farmers have been able to dramatically increase milk production over the years. We expect that, as research continues, further benefits will accrue both to the dairy industry and to the consumer.

The Nutritional Value Of Maturing Forage Crops

R. A. DVORAK and D. A. MILLER

FORAGES PROVIDE a large share of the nutrition that ruminant animals need. For beef cattle, forages comprise about 73 percent, by weight, of the diet; for sheep, 80 percent, and for dairy cows, 63 percent.

Since the nutritional needs of livestock change during phases of growth, and since the nutritional values of forage crops change during maturation, the livestock producer must coordinate the harvesting and feeding of forages with his livestock's changing needs.

When an animal's protein and energy needs are low, some nutritional quality in the forage can be sacrificed in favor of high yields by harvesting at a late stage of maturity. When the animal's nutritional requirements are high, as in late gestation and lactation, forages need to be harvested early.

Nutritional contents

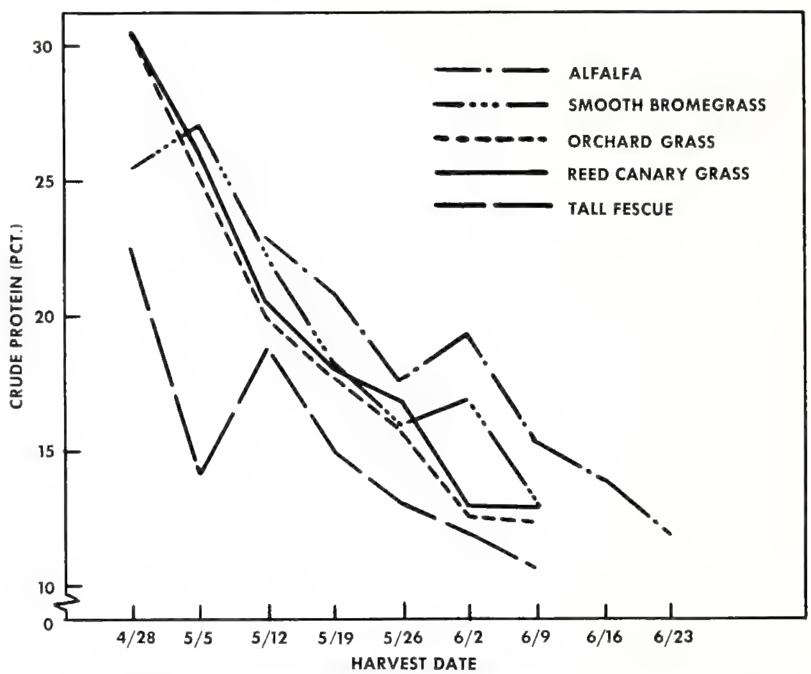
When to harvest which forage crop is at present impossible to determine precisely. We don't know the exact way in which advancing maturity affects the cell wall composition of the major Illinois forages — alfalfa, orchard grass, smooth bromegrass, tall fescue, and reed canary grass.

We do know that the crude protein content of a forage, as well as its level of digestible energy, diminishes as fibrous cell wall components increase with maturity. These changes in nutritional value can be traced by the forage analysis scheme developed by Dr. P. J. VanSoest in the early 1960's, which separates highly available components from partially available components in feed by their solubility in a neutral detergent solution.

The highly soluble cell contents — starches, sugars, proteins, lipids, and other solubles — are 98 percent digestible by both ruminant and nonruminant animals. The less soluble cell wall contents — cellulose, hemicellulose, lignin, and heat-damaged protein — are 40 to 80 percent digestible by ruminants only, depending upon plant maturity.

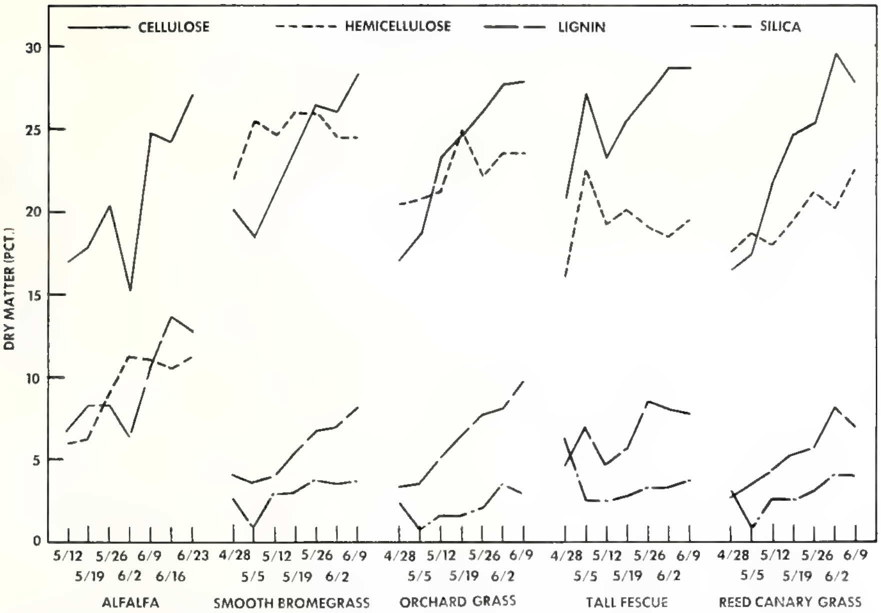
Table 1. — Descriptions of Forage Samples at Each Harvest Date

Harvest date	Alfalfa	Smooth bromegrass	Orchard grass	Tall fescue	Reed Canary grass
4/28	...	Vegetative	Vegetative	Vegetative	Vegetative
5/5	...	Early boot	Boot stage	Early boot	Vegetative
5/12	Bud stage	Late boot	Heading	Boot stage	Vegetative
5/19	Bud stage	Early heading	Fully headed	Late boot	Flag leaf
5/26	5% bloom	Fully headed	Flowering	Fully headed	Early heading
6/2	20% bloom	Early flowering	Early seed	Early flowering	Flowering
6/9	50% bloom	Late flowering	Milk stage	Early seed	Late flowering
6/16	Full bloom	...	...	...	...
6/23	Early seed	...	...	...	...



Changes in the crude protein content of various forage crops with advancing stages of maturity. (Fig. 1)

R. A. Dvorak is instructor of animal science; D. A. Miller is professor of plant breeding and genetics. The authors wish to thank Dr. F. C. Hinds for the use of laboratory facilities.



Changes in the cellulose, hemicellulose, lignin, and silica contents of various forages with advancing maturity. (Fig. 2)

tall fescue was residual from the fall. Since legumes contain less than 1 percent silica, alfalfa was not analyzed for silica.

Alfalfa contained more lignin and less hemicellulose than the grasses. High digestibility of alfalfa is due to a lower level of cell wall constituents (Fig. 3).

Necessary information

For proper forage management, a livestock producer requires the type of information that this study provides. Using data on the nutritive value of forage crops through the growing season, plus livestock production data, a cattleman or sheepman could determine when to harvest the best species for his livestock's needs.

We need more knowledge about the effects of both the growth environment and the stages of maturation upon the nutritional value of each forage species. Team research by the agronomist and the animal scientist is necessary to provide this information and to permit the best possible coordination of forage crop harvest with the animal's nutritional requirements.

Illinois study

We sought (1) to determine the effect of plant maturation on levels of crude protein and cell wall components for each species and to compare species, and (2) to determine changes in dry matter digestibility within and across species.

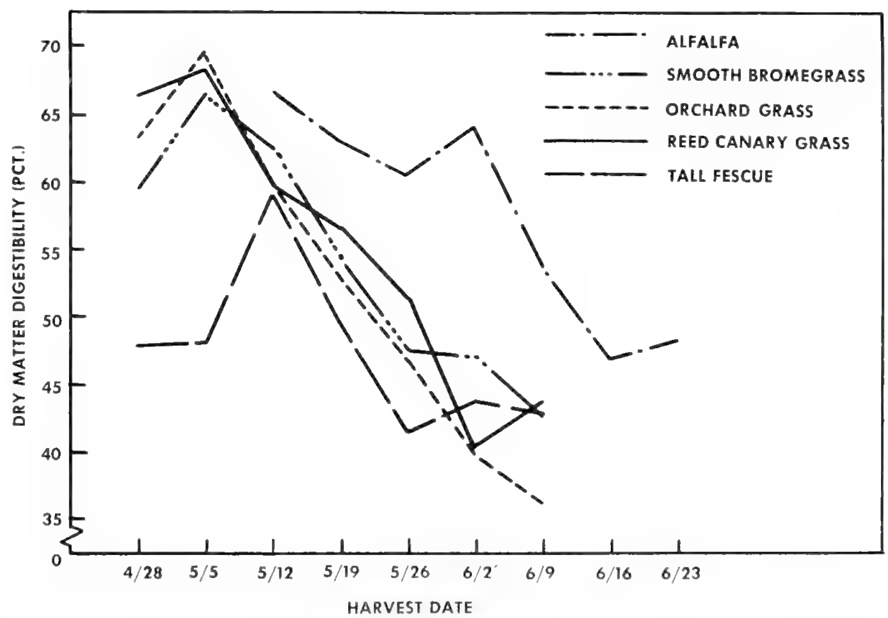
The schedule of weekly harvests and a brief description of the samples collected from each harvest are given in Table 1. Plants ranged in maturity from the vegetative to the late-flowering, early-seed stage.

Samples were analyzed for crude protein (Kjeldahl procedure for determining nitrogen), for cell wall components (VanSoest analysis), and for apparent dry matter digestibility (VanSoest's equation using cell wall components as variables).

Effects of maturity

Crude protein was highest at first cutting and decreased linearly and at a similar rate for all species as plants matured (Fig. 1). Reed canary grass, orchard grass, and smooth bromegrass were similar in crude protein content. Tall fescue was generally lower in crude protein than these varieties, and alfalfa was higher.

Cell wall components — cellulose, hemicellulose, and lignin — plus silica changed at different rates in each species (Fig. 2). Cellulose and lignin increased linearly, while the growth of hemicellulose was curvilinear. Silica content was uniform for all species, rising slightly over the season. The early high content of silica in



Changes in dry matter digestibility with advancing plant maturity, as estimated by VanSoest's equation. The percentage of dry matter digestibility = 0.98 (100 — CWC) — M + CWC (1.808 — 0.966 log L) — 3.0 (SiO_2), where CWC is the cell wall constituents and M is the metabolic fecal loss. (Fig. 3)

Soybean Crop Gains Value With Feeding Of Harvest Residues

F. C. HINDS

VALUABLE as the soybean crop now is to Illinois farmers, it could be even more valuable if the harvest residues were fully utilized as livestock feed.

Research on the feeding value of soybean harvest residues goes back as far as 1925. That year, Kammlade and Mackey of the University of Illinois found that lambs readily accepted "soybean straw" and that it served as a reasonable roughage for finishing lambs.

Later, again at Illinois, Hamilton and coworkers (1928) found soybean straw to be 40 percent digestible. They believed that, because of its physical character, it should be ground for complete consumption. From 1928 until the 1970's, essentially no new work was reported on the subject.

Since 1970, research on soybean harvest residues has been revived at the University of Illinois, so that we now know much more about their effective utilization.

Collection and storage

Generally, the yield of residues is about 1 ton of air-dry material per acre, but this varies with the collection system. Yields are highest when residues are collected in a dump cart pulled behind the combine at harvest time. However, stackers or round balers are more commonly used. They will pick up most of the residues if collection is done immediately after harvest. Delaying collection will reduce yield and possibly nutritive value.

Because the bales and stacks are porous, they should be protected from the weather until the residues are fed. A simple straw shed is adequate shelter. The residues are dry enough at harvest to keep without spoilage, so special treatment or storage facilities are not needed.

Digestibility and nutrients

Recent studies on residues collected with dump wagons indicate that the digestibility ranges from 35 to 50 percent. This range is largely due to two factors.

First, grinding before feeding may increase digestibility from about 35 percent to nearly 45 percent.

Second, the final ratio of pods to stems influences digestibility. In normal material collected with a dump cart, 30 to 35 percent of the dry matter will be pods and the remainder, stems. Laboratory studies indicate that 65 to 70 percent of the pods are digested, as compared to only 30-35 percent of the stems. Thus, collection methods that increase the proportion of pods will likely provide the most digestible residue. Using specially modified dump wagons, we increased the percentage of pods in the residue to as much as 50 percent, while only slightly reducing the yield.

The crude protein content of residues is low (4 to 5 percent) and less than half of the protein is digestible. Beta-carotene is completely lacking. Supplemental protein and vitamin A must therefore be provided when the residues make up the major part of the ration. Minerals, mainly calcium, phosphorus, sulfur, magnesium, manganese, and zinc, will also need to be provided by supplemental sources.

Importance of grinding

Besides improving digestibility, grinding increases the consumption of the residue. It also facilitates the mixing of supplements and residues, reducing the possibility of the supplements becoming separated from the residue when a complete mixed feed is fed. The grinding should be fairly fine, preferably through a ½-inch screen or less.

Possible uses

There are two places in ruminant feeding where soybean harvest residues seem to fit. The first is in a high-concentrate finishing ration. According to research with finishing rations for cattle and lambs, gains are usually fastest when 5 to 15 percent of the high-concentrate ration is a roughage.

At this low level, the roughage is providing a non-nutritive benefit; its nutritive quality does not influence gains. Thus, ground soybean harvest residues will serve the same purpose as much higher quality roughages. However, if roughage makes up more than 15 percent of the ration, its nutritive quality becomes important.

The second place where the residues can be used is in feed for beef cows and ewes. Here residues, properly supplemented, can serve as a partial or complete replacement for hay or other roughages.

The value of soybean residues in feeding programs was clearly demonstrated in 1974, when weather conditions made hay-making impossible in parts of Illinois, and hay prices soared. A number of producers successfully used supplemented residues as a hay extender or as a complete replacement. Some few producers now use fairly large amounts of residues in feeding their brood animals. Soybean harvest residues are sometimes grazed, but this is not an effective method of maximizing their utilization.

The true potential for utilization has just been scratched. If only half of the residues from the present soybean crop were used properly, they would support an additional 500,000 beef cows per year. Such a resource cannot long be overlooked with the present call for general economy and efficient resource utilization.

F. C. Hinds is professor of animal science.

College Students of Today

K. E. GARDNER

WHAT is the present generation of college students like? A partial answer emerges from data compiled in the College of Agriculture.

How many — what background?

In August, 1975, the College registered 2,411 students, of whom 1,701 were in agricultural curricula and 710 in home economics. Enrollments have not risen perceptibly for three years because of the static enrollment policy on the Urbana campus. The freshman class totaled 681, including 366 new agriculture students, 143 new home economics students, and 172 who had entered earlier but had not finished one year's work.

Each year, a slightly smaller percentage of the students in the agricultural curricula are of farm origin. This is mainly due to the greatly increased interest of urban students in such subjects as forestry, ornamental horticulture, and food science. The "farmers" comprised 37 percent of the 366 new agricultural students. Of those with a farm background, 90 percent had belonged to 4-H clubs and 70 percent to the Future Farmers of America.

Sex ratio

An important change in the College has been in the ratio of men to women. At one time, colleges of agriculture were heavily loaded in favor of the male sex, even though home economics students were included. At present, some 28 percent of the students in the agricultural curricula are female. In the College as a whole, including home economics students in the School of Human Resources and Family Studies, the ratio is about 52 percent male and 48 percent female.

How smart are they?

The average (median) student who entered as a freshman in 1975 ranked in the 80th percentile of his high school class, or in the top 20 percent. The average student on the entire Urbana campus ranked in the 90th percentile. The median American College Testing (ACT) composite score for students in the College of Agriculture was 24 and in the University it was 26, which is an unusually high average figure.

Despite the stiff competition on the campus, most of our students in agriculture do well. Of the class that entered in 1974, for example, 73 percent were on "clear" status at the end of their first year; 15 percent were placed on probation as a warning that they were falling behind; 8 percent were dropped by the college; and 4 percent dropped out for various reasons. Many of those who are dropped return after a semester or two to try again, often very successfully.

Objectives

During Freshman Week in 1975, nearly half of the first-year students in the College of Agriculture completed a comprehensive questionnaire developed by the American Council on Education. Of those answering the questionnaire, 43 percent planned to stop with the B.S. degree and 25 percent with the M.S. degree; while 22 percent of both sexes wanted to go on to a Ph.D.

Asked about their ultimate objectives, 70 percent said they wanted to become "an authority in my field," and 25 percent hoped to have administrative responsibility. Altruism was quite in evidence, since 55 percent hoped to "help others in difficulty" and 30 percent wanted to participate in community action.

How well prepared?

Nearly half the males and 36 percent of the females answering the questionnaire felt "very well prepared" for science. In vocational skills, 27 percent of the males and 19 percent of the females felt they had some real competence.

Some 32 percent of the females, as compared to only 18 percent of the males, felt that high school had prepared them well for reading and composition. Three times as many females (34 percent) as males (11 percent) felt well prepared in foreign languages.

Financial status

Three-fourths of the students said that their parents' income exceeded \$15,000, and for a quarter of the students, family income was over \$30,000. Nearly 30 percent of the students had state scholarships or grants, while only 4 percent received federally guaranteed loans and 4 percent received national direct student loans. About 75 percent of the students expected to work part time during the year.

Politically moderate

Politically, 54 percent of these freshmen considered themselves "middle-of-the-road," 18 percent said they were conservatives, and 26 percent labeled themselves as liberal.

One interesting difference between males and females was that the males tended to be more "authoritarian." Twenty-seven percent of the males felt that the College should have the right to ban a speaker, whereas only 10 percent of the females shared this belief. Some 63 percent of the males, but only 34 percent of the females, felt that criminals have too many rights. Of the males, 69 percent felt that large families should be discouraged, as compared with 56 percent of the females.

In summary, it seems that these entering students, like those before them, are ready to work hard and to accept their responsibilities.

K. E. Gardner is director of resident instruction and associate dean.

FARM BUSINESS TRENDS

In recent years the output of U.S. agriculture has had a strong upward trend. Crop production was 31 percent higher in 1975 than in 1960 (see chart). As an example, the corn crop, which was 3.9 billion bushels in 1960, reached a record 5.77 billion bushels in 1975.

The growth in production since 1960 has been primarily due to a higher output per acre. Production per acre was 27 percent greater in 1975 than in 1960; land used for crops, only 4 percent greater.

For a number of years during the 1960's, with the governmental programs in effect, land used for crops dropped 5 to 6 percent below the 1960 level. In recent years there have been no programs to restrict the extent of crop production.

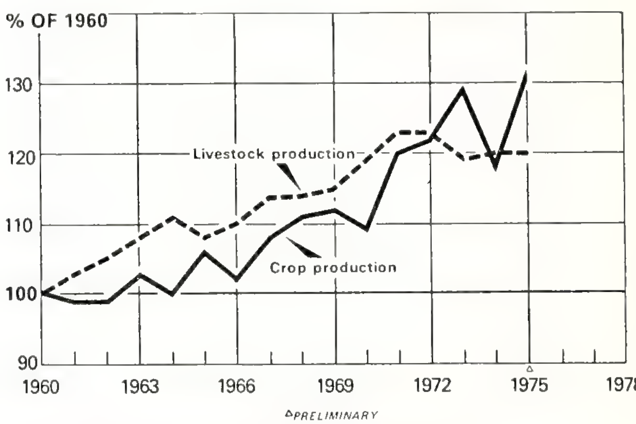
Livestock production was 20 percent greater in 1975 than in 1960 (but not as great as in 1971 and 1972). Beef production in 1960 was 14.7 billion pounds, or 85 pounds per person; in 1975, 23.8 billion pounds for a per capita supply of almost 120 pounds. A major factor in the recent leveling-off of livestock production was the short grain crop of 1974. Hog production had to be cut sharply in order to balance livestock with available grain. In 1975 hog production was at its lowest level since the 1930's. A substantial build-up in hog numbers is now under way.

While increases in production have been large, the expansion in markets has also been great. Much expansion resulted from the 18 percent growth in domestic population. In addition, foreign markets for U.S. crops are growing tremendously. For the crop year beginning October 1, 1960, corn exports totaled 292 million bushels. For the year beginning October 1, 1975, they will be near 1.65 billion bushels.

Expanding markets have not only taken care of production, but have also reduced the grain stocks in storage. In the crop year beginning October 1, 1961, the carryover of corn was at a record level of just over 2.0 billion bushels, of which nearly 1.9 billion bushels was owned by the government or was under loan. On October 1, 1975, the carryover was only 359 million bushels. For wheat, the carryover on July 1, 1961, was also at a record level — 1.4 billion bushels. On July 1, 1975, the carryover of wheat was 327 million bushels, but it will increase for 1976.

The expanding production and markets have resulted in erratic and unstable prices for agricultural commodities. Farmers have had to devote more attention to decisions on buying and selling. No longer can a sales program be by intuition alone; it needs to be part of an overall, soundly conceived plan.

The variety of information that farmers need includes supplies of a product, business conditions that may affect demand, and many international developments. A special concern in this period of closely matched supply and demand is weather conditions both domestically and internationally. This year, unfavorable crop conditions could cause a cutback in the expanding livestock feeding programs that are now under way. To make sound decisions in this confusing time, a farmer must become a businessman with an international awareness. — *M. B. Kirtley, Extension economist, livestock marketing.*



U.S. crop and livestock production, 1960-1975.

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ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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THE NEW PLANT CLINIC

The plant clinic, a new facility of the University of Illinois, successfully concluded its first season of operation in September. Supported by both the Agricultural Experiment Station and the Cooperative Extension Service, it has a two-fold purpose — to provide a service to the people of Illinois and to identify areas of needed research.

All plant specimens sent to the University for identification of a plant disease, insect damage, chemical injury, or any other problem are routed to the clinic. The requested information is provided through the cooperative efforts of several departments in the University and the State Natural History Survey — plant pathology, entomology, agronomy, botany, horticulture, forestry, and agricultural engineering.

Last summer the clinic handled well over 1,500 specimens. After a receptionist logged in the samples, staff members and graduate students from the cooperating departments examined the specimens and conducted the tests necessary to make the requested identifications.

No serious insect problems were observed during the season. Nor, because of the dry summer, did any critical disease problems develop. However, about 20 new or unusual diseases that will bear future watching were identified.

In addition to the work of the clinic itself, the building is providing an opportunity for research on solar heating. Plexiglass panels on the south side of the building are trapping solar energy to provide part of the heating requirement. The building has been closed this winter so that agricultural engineers can collect base-line data for evaluating energy savings in future years.

When the clinic reopens next spring, we hope both to expand and to speed up our service. As more and more samples are analyzed, we will accumulate information on where and when to expect specific problems associated with growing all types of plants, as well as on the type of research that can be done to further benefit the people of Illinois. — *Benjamin A. Jones, Jr., Associate Director, Agricultural Experiment Station*

Soybean Inoculation: Is It Necessary?

Seed do not need inoculation if the soil has grown a well-nodulated crop within the past five years and is not strongly acid

R. R. JOHNSON and L. V. BOONE

IN A TYPICAL Illinois soybean field, about half of the nitrogen used by the plants comes from the soil. The rest comes from the air through symbiotic nitrogen fixation. This is a cooperative relationship occurring in the root nodules. The plant provides food for bacteria called rhizobia, which in return fix nitrogen from the air into forms that the plant can use.

The species of rhizobia that fixes nitrogen in soybeans is called *Rhizobium japonicum*. It is different from those that fix nitrogen in alfalfa and other legumes. Thus, the bacterial inoculum used for soybeans should not be used for alfalfa and vice versa.

Symbiotic nitrogen fixation begins 3 to 4 weeks after planting and continues to near maturity, with peak activity occurring near the late flowering and early podding stage. Therefore, one can determine if the crop is nodulated by inspecting plant roots at various times during the growing season (Fig. 1). The best time is mid-July or early August, when the volume of nodules is usually greatest.

The size of individual nodules is of little importance; total volume or weight of nodules per plant is the best indicator of adequate nodulation. A low number of nodules is not always due to a lack of appropriate rhizobia. Long dry periods and high levels of available soil nitrogen, among other factors, can reduce nodule mass and nitrogen fixation.

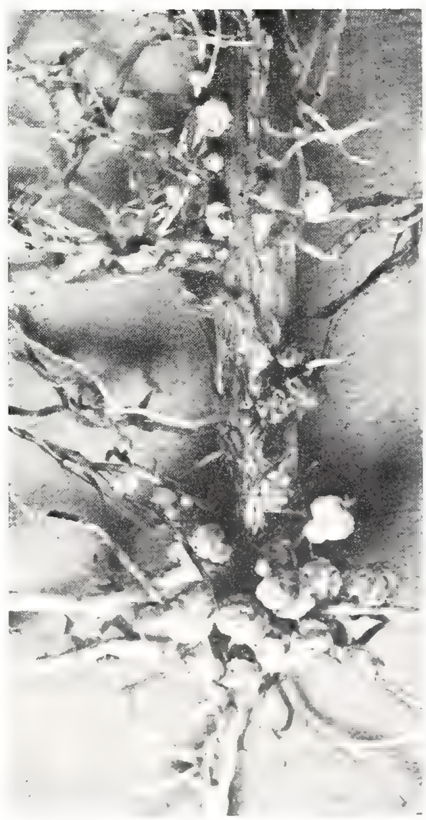
R. R. Johnson is assistant professor of crop production and L. V. Boone is agronomist.

Seed treatment inoculums

Corn Belt soils contain several different strains of *R. japonicum*, and some soybean varieties seem to interact with a given strain more effectively than with others. For this reason, commercial soybean inoculums are generally mixtures of different *R. japonicum* strains.

Originally, U.S. soils did not contain a natural rhizobia population. The strains now in our soils were established largely from seed that had been treated with commercial inoculums. In a recent Iowa survey, soils previously cropped to soybeans were found to contain about 64,000 rhizobia per teaspoon of soil. This indicates that a tremendous natural population of rhizobia has been established in Corn Belt soils.

Rhizobia also survive and spread without the use of commercial inoculums. This phenomenon was demonstrated on the Morrow Plots, which have detailed cropping records for the past 100 years. Soybeans were first grown on these plots in 1968, with inoculated seed planted on some plots and uninoculated seed on others. Both inoculated and uninoculated plots averaged 48 bushels per acre and both were well nodulated. Bacteria had apparently entered the soil through such means as farm machinery and wind erosion.



Nodules on a soybean root system early in the growing season. (Fig. 1)

With the high natural populations of rhizobia now in soybean-producing areas, the question arises as to whether inoculation is necessary. A study at Hartsburg, in an area where soybeans had been grown in the pre-

Table 1. — Effect of Soybean Seed Treatments on Seed Yield at Hartsburg

Treatment	Yield, bu./A.		
	1973	1974	Aver.
None	58	33	46
inoculum	58	34	46
Fungicide	58	34	46
Inoculum + fungicide	58	33	46
Inoculum + fungicide + Mo	60	36	48

Table 2. — Effect of Seed Treatments on Yields at Four Soil pH Levels (3-Year Averages at Brownstown)

Treatment	Soil pH			
	4.9	6.5	7.1	7.9
	bu./A.			
None	24	36	35	35
Inoculum	26	33	32	34
Inoculum + fungicide	24	33	32	34
Inoculum + Mo	34	35	32	33
Inoculum + fungicide + Mo	31	33	33	34

Table 3. — Yield of Three Soybean Varieties Receiving Different Inoculum Treatments

Treatment	Urbana		Hartsburg		Aver.
	Corsoy	Williams	Amsoy 71	Williams	
			bu./A.		
None	58	53	44	48	51
Seed coat (inoculum)	58	52	47	43	50
Granular implant inoculum					
5 lb./A. Nitragin	58	57	47	45	52
10 lb./A. Nitragin	59	55	43	44	50
6 lb./A. Kalo K1170475	58	56	49	44	52
12 lb./A. Kalo K1170475	59	63	46	42	52

vious three to five years, showed no yield response due to inoculation and other seed additives (Table 1). There was a slight response to molybdenum in the inoculum mixture, but this was not significant.

A greater response to molybdenum in the seed-treatment mixture was demonstrated by D. E. Millis and F. E. Zajicek at Brownstown on soil with a low pH (Table 2). Since there was no treatment including only molybdenum, we do not know if inoculum was also necessary for this yield response. It is known, however, that the survival of rhizobia and the availability of molybdenum both decrease as soil pH declines. Molybdenum is important for nitrogen fixation because it is a cofactor in the biochemical pathway of fixation. The yield advantage due to a mixture of molybdenum and inoculum was lost when the soil was limed to a proper pH (Table 2).

Granular inoculums

Seed treatment inoculums supply, at the most, a few hundred thousand bacteria per seed. This is a relatively insignificant number when compared to the several millon bacteria per root system already in most soils where soybeans have been grown. However, in the past, due to low costs, some people have recommended seed treatment inoculums as a cheap insurance.

Recently a new method of applying rhizobia has been developed that permits application of several million bacteria per inch of row. In this system, granules of inoculum are applied through the insecticide attachment on the planter, but at current prices this practice can no longer be classified as cheap insurance.

To determine if the new soil implant inoculums would be beneficial on fields where soybeans had been grown within the last five years, two products were applied at their recommended rates and at double these rates (Table 3). One of the products, nitragin, is commercially available; the other, Kalo K117045, is still in the experimental stage.

The inoculums did not significantly affect seed yield at either Urbana or Hartsburg. Nor did they affect lodging, date of maturity, and percentages of protein and oil.

It thus appears that soils which have grown nodulated soybean crops within the last five years do not respond to even massive rates of inoculum supplied by granular implants.

Fertilizer nitrogen and nodulation

Additional evidence that nitrogen fixation is not usually limiting is the failure to obtain yield increases by adding fertilizer nitrogen to the soil. In the Urbana field where the granular inoculum study was conducted, 0, 100, and 400 pounds per acre of nitrogen were applied to the Clark nodulating and non-nodulating varieties. No inoculum was used in this experiment. The two varieties are the same, except that the non-nodulating variety has a gene which prevents the formation of nodules.

Without fertilizer nitrogen, the nodulating variety produced 40 bushels per acre. This was not significantly increased by nitrogen fertilizer. At both levels of application — 100 and 400 pounds — yields were 42 bushels per acre. Obviously, the nodules had produced adequate nitrogen.

However, fertilizer did significantly increase the yield of the non-nodulating variety. Yield on the unfertilized plot was 33 bushels per acre. This was increased to 38 bushels by 100 pounds of fertilizer per acre, and to 41 bushels by the 400-pound application.

Recommendations

According to these studies, soybean seed do not need inoculation when the soil has grown a well-nodulated crop within the previous five years and is maintained at a proper pH. If soybeans are being grown for the first time or if the previous crop was poorly nodulated, inoculum is recommended.

Seed treatment inoculums should be applied immediately before planting because bacteria soon die when exposed to dry conditions, high temperatures, and sunlight. Granular implant inoculums will supply more bacteria and may save time at planting. However, if one switches from seed treatment to granular implant inoculums, the cost will jump from a few cents to several dollars an acre.

The Quality of Concentrated Skim Milk Sterilized at Ultra-High Temperatures

R. McL. WHITNEY, G. V. REDDY, J. V. LIN, and S. J. TYNER

Evaporated milk sterilized in the can has been manufactured and distributed commercially for more than 100 years. Since it is sterile, it can be stored for long periods at room temperature without bacterial deterioration and, since some of the water has been removed by evaporation, the costs of handling and transportation are less than for the same quantity of nutrients in whole milk.

Unfortunately, the caramelized off-flavors developed in this product during processing and storage have largely limited its use to cooking, infant formulas, or situations where refrigeration is not available, such as camping. To overcome this limitation, ultra-high temperature processes have been developed for sterilizing concentrated milks, followed by aseptic canning. These products have enough acceptance to justify marketing; however, they may develop two defects which detract from their acceptability — protein sedimentation and gelation upon storage.

These defects have been shown to be related to the size distribution of the large protein particles or micelles that are formed during processing, and also to changes in the micelles during storage. Although little is known about the mechanisms involved, the distribution of salts between the serum and the micelles is believed to be involved in these phenomena. We have therefore attempted to relate changes in salt distribution to changes in the number and size of the micelles.

A typical experiment

In a typical experiment, milk was preheated to 87°C. (189°F.) with no holding time. It was then cooled to 50°C. (122°F.) and separated into cream and skim milk. The skim milk was concentrated to 38 percent total solids, sterilized at 155°C. (310°F.) with no holding time, and canned aseptically. The cans of the product were then stored at 37.7°C. (100°F.), 23.3°C. (74°F.), and 4.5°C. (40°F.).

During processing, samples of the original skim milk and the condensed skim milk before and after sterilization (diluted 1:4) were separated into serum and protein micelles by ultracentrifugation at 55,474 times the force of gravity. The samples and serum were analyzed for calcium, magnesium, inorganic phosphate, citrate, chloride, protein, and non-protein nitrogenous material. Simultaneously the size distributions of the large protein micelles in the samples were determined by a Coulter Counter. At suitable intervals, cans of the sterile concentrated skim milk were removed from storage, diluted, and analyzed in a similar fashion.

Changes with condensation

While the number of micelles in the counting range did not increase upon condensing, their average volume increased from 6.12 to 7.42 cubic microns. At the same time, some of the calcium in the serum shifted to the micelles, the amount in the serum declining from 372.7 to 298.8 milligrams per liter. This shift may explain the growth of the particles. Since the micelles are negatively charged, their binding of the positively charged calcium ions would reduce the micelles' charge and allow more protein to adsorb on their surfaces.

Changes with sterilization

Upon sterilization, the number and size of the micelles in the counting range greatly increased (from 14 billion per liter and an average volume of 7.42 cubic microns, to 2,655 billion per liter and an average volume of 8.51 cubic microns). At the same time inorganic phosphate shifted from the serum to the micelles, the amount in the serum declining from 269.2 to 220.7 milligrams of phosphorus per liter. This shift suggests that calcium phosphate bridges were formed between the micelles, causing the large increase in micelle size.

Changes during storage

In storage, changes were more complex. During the first 5 days, regardless of temperature, the number and average volume of the micelles in the counting range decreased to 1,510 billion per liter with an average volume of 6.03 cubic microns. On further storage, the micelles joined together in chains, the onset and degree of chain formation varying with the temperature. Continued chain formation finally resulted in gelation. This occurred after 20 days at 37.7°C. and after 60 days at 23.3°C. The product remained fluid when stored under refrigeration at 4.5°C.

Another change during storage was in the nonprotein nitrogen content. Within the first 5 days, it increased sharply — from 0.265 to about 0.345 gram per liter, indicating a breakdown of the proteins. This breakdown is possibly due to action of the enzyme protease, either because it is not inactivated by the heat treatment or because it is reactivated upon storage. Such a breakdown might explain the decrease in micelle size during this same period of storage and would result in the formation of new surfaces.

(Concluded on next page.)

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Calcium and magnesium ions moved from the serum to the micelles during storage, the rate of movement depending on the temperature. The serum calcium content changed from 304.4 to 200 milligrams per liter in 20 days' storage at 37.7°C.; to 186 in 60 days at 23.3°C.; and to 240.9 in 60 days at 4.5°C. The shift in magnesium ions was comparable.

In contrast, the direction of movement of citrate and inorganic phosphate varied with the temperature. At 37.7°C., the inorganic phosphate content of the serum decreased from 220.7 to 196.9 milligrams of phosphorus per liter in 20 days, while at 4.5°C. it increased to 236.4 milligrams of phosphorus per liter in 60 days. Very little movement was observed at 23.3°C. Similar behavior was observed for the citrate ion.

This complex movement is difficult to explain, but the new protein surface formed by the protease should provide new binding sites for calcium and magnesium on the micelles. Then, as phosphate and citrate move into the micelles, bridges could be formed resulting in chain formation and gelation. The rapid gelation at 37.7°C. may be due to the greater movement of phosphate and citrate into the micelles at that temperature, combined with the accelerated movement of calcium and magnesium. The retardation or prevention of gelation at refrigeration temperatures may be explained by the movement of phosphate and citrate out of the micelles at 4.5°C.

More work needed

Much more work needs to be done before definite conclusions can be reached about the mechanisms governing the changes in micelle size during processing and storage. As further research yields the necessary answers, we will be able not only to explain why sterile concentrated milk gels on storage but also to develop means of preventing gelation. Then a product acceptable for all uses, which will not require refrigeration and can be economically transported and handled, will be available to the public.

Ten Days in the Life of A Germinating Soybean Seed

DANIEL C. ADJEI TWUM and WALTER E. SPLITTSTOESSER

GERMINATION includes all the steps from the time a seed imbibes water until the seedling is self-sustaining. During germination, the seedling is dependent upon stored material in the seed. If the seed is planted too deep, its stored energy will not be great enough to allow the seedling to emerge.

The major metabolic processes associated with seed germination are the hydrolysis of stored materials in the reserve tissue and their translocation and use by the developing seedling. Some of the amino acids liberated from the reserve protein are utilized in the synthesis of enzymatic proteins in the cotyledons, or primary leaves.

We have recently studied the biochemical changes and the interrelationship of these changes in germinating soybean seeds. Our purpose was to estimate the interconversion and translocation of the various components.

How study was done

Amsoy soybean seedlings were grown in vermiculite in the dark at 28°C. At various times seedlings were removed, washed in water, and separated into roots, shoots, and cotyledons.

The component parts of some of the seedlings were cut into small pieces, boiled in 80-percent ethanol, and ground in a homogenizer. The homogenate was centrifuged and the precipitate re-extracted with hot 80-percent ethanol, deionized water, and 80-percent ethanol, and recentrifuged. The soluble fraction contained the soluble carbohydrates and the free amino acids. The insoluble precipitate contained the insoluble protein, DNA, and RNA.

Another group of seedlings was extracted with chloroform, methanol, and water to remove the total fats. A third group of seedlings was used to determine water content, total dry weight, and total nitrogen in roots, shoots, and cotyledons.

Dry weight

During the 10-day growth period, dry weight decreased by 25 percent in the whole seedlings and by 70 percent in the cotyledons (Fig. 1-1). Dry weight accumulated in roots and shoots. Their growth and development was supported by the storage reserves at the expense of the cotyledons. The decrease in dry weight of the whole seedling was mainly due to the loss of carbon atoms through respiration.

Water and nitrogen content

Water inhibition is essential for activation of germination in dry seed and for hydrolization and translocation of reserve materials to the root and shoot. The seedlings took up water rapidly and the water content of the whole seedlings increased as germination proceeded (Fig. 1-2). A parallel increase occurred in the root and shoot.

About 10 percent of the total nitrogen was lost from the whole seedlings over the germination period (Fig. 1-3). Some of the nitrogen may have been leached out. The cotyledon lost 65 percent of its nitrogen.

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The lost nitrogen was transported to the root and shoot.

Carbohydrates and fats

Carbohydrates are hydrolyzed in storage organs of germinating seeds and translocated to roots and shoots. These compounds are utilized as an energy source and provide carbon skeletons for the synthesis of new constituents.

Soluble carbohydrates in whole seedlings decreased 75 percent during the first 3 days of germination, increased slightly to a peak 6 days after sowing, and then declined again (Fig. 1-4). A parallel pattern was followed in the cotyledons. A 6-fold increase occurred in the root and shoot during the first few days of germination.

About 75 percent of the fats in cotyledons was depleted over the sampling period (Fig. 1-5) without accumulating in either the root or shoot. The fat content of the root and shoot remained low. Fats are important storage material in soybeans and are converted to sucrose, resulting in the slight increase in soluble carbohydrates in whole seedlings and cotyledons between 3 and 6 days after planting.

Amino acids and protein

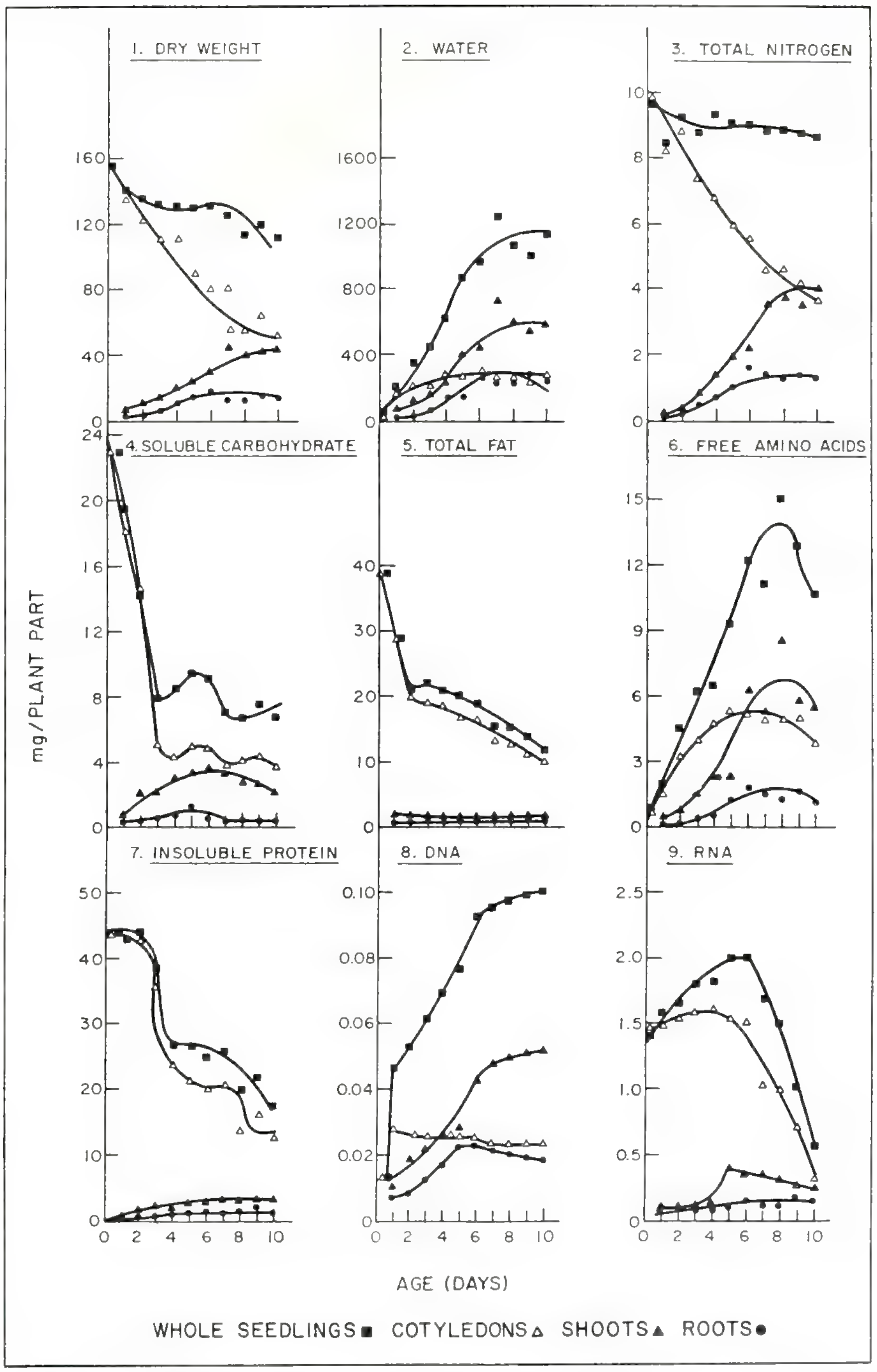
Free amino acids in all components of the seedlings increased rapidly during germination (Fig. 1-6). At the same time, reserve protein (insoluble protein) decreased in the whole seedlings and cotyledons (Fig. 1-7).

Protein reserves in germinating seeds are hydrolyzed to amino acids, which are transported to the axis tissue and used for growth or as an energy source. Since amino acids are normally transported from the cotyledon soon after they are released from the protein reserve, they accumulate in the cotyledon more slowly than in the root and shoot.

DNA and RNA

DNA content of whole seedlings, roots, and shoots rapidly increased (Fig. 1-8) because of active cell growth. Since cell division in cotyledons does not normally occur during germination, an increase in cotyledonary DNA was not expected. Cotyledon levels remained fairly constant over germination.

The RNA content of the seedling increased to a maximum 5 days after planting, and then declined rapidly so that a net decrease was observed by 10 days (Fig. 1-9). Because RNA is involved in the synthesis of various cell constituents, the RNA content of the shoots increased during the initial stages of growth. RNA then declined as the percentage of mature tissue to actively growing young cells increased.



Changes in various constituents of germinating soybean seedlings. **(Fig. 1)**

Space Age Electronic Controls Operate Automatic Lamb and Ewe Feeding System

E. F. OLVER, H. B. PUCKETT, F. C. HINDS, and J. M. LEWIS

For centuries, sheep have been raised on the open range. But changes in the rules governing the control of predators have resulted in high death losses among lambs and ewes in the United States. Some ranchers have been forced out of business, while others have switched from open range to closed range and finally to confinement rearing to regain profitable production.

Confinement lamb rearing systems have been pioneered by the Illinois Agricultural Experiment Station at the Dixon Springs Agricultural Center (DSAC). The original objectives were to eliminate the predator problem and to achieve a more rapid weight gain on selected rations. Part of the increased gain would be due to a reduction in the number of parasites transmitted from adult sheep to lambs in a common grazing situation.

Confinement rearing of lambs and ewes has advantages, but it also has the disadvantage of increased labor to process and distribute feed. After many discussions, animal scientists and agricultural engineers developed a plan to automate the delivery and proportioning of concentrates and forage fed to lambs and ewes in confinement.

Experience gained from several years' research in mechanized dairy cow feeding has been valuable. The methods of ingredient storage, withdrawal from storage, proportioning, and delivery developed for dairy cow feeding satisfy the needs of the lamb and ewe feeding systems.

Faults of earlier systems

A challenging problem was to improve the reliability and serviceability of the electrical control system. Automatic machine control relay systems had earlier been adapted to meet the needs of agricultural process control, but these systems had two main faults: First, they were difficult to install because the wiring was complicated for an electrician not familiar with the particular system. Second, the dirty and corrosive environment of the farm caused contact failures which were hard to diagnose.

A control system was needed that was flexible, reliable, durable, and easy to maintain. This became possible with a new development in computer technology — the programmable sequence relay controller.

Characteristics of controller

The programmable sequence relay controller permits the user to program a control system with a set of keyed-in instructions somewhat as one would program a small calculator.

The heart of the controller is a microprocessor, a small integrated circuit similar to that used in the small four-function pocket calculator. A memory which contains the coded instructions for the microprocessor represents the wiring paths of the relay logic system. The microprocessor compares the status of the inputs (system control switches) to that specified in the coded instructions of the memory. If all conditions are met, the microprocessor initiates a command sequence to perform a desired service based on the status of the inputs. The system may control one to several hundred power relays. By changing the computer instructions, the operator can effect any type of control sequence he desires within the limitations of the memory.

The system offers maximum flexibility in automatic control with a minimum number of components. The small number of standard parts needed for the simplest to the most complex relay control systems means low cost, easy maintenance, and less "down-time" for the user. The installer can quickly tailor these control systems on the site, and the "read/write" memories permit the operator to do the same with simple instructions.

Controller at Dixon Springs

The programmable sequence controller used for the lamb and ewe feeding system at DSAC has 64 input signals for selector switches, limit switches, motor overloads, and various safety and bin switches. In various combinations, the inputs instruct the computer to operate one or more of the 16 outputs. The outputs are motor starters, transfer solenoids, signal lights, and bells.

The control system can cause feed to be withdrawn from one harvestore and three concentrate bins for automatic delivery to the pens. One ingredient can be proportioned with any or all of the other three ingredients. Since all rations normally contain forage, an electronic scale uses forage flow to control the instantaneous flow of the concentrates.

The blended ration can be delivered to 24 specific 10-foot pens in the confinement building. (The pens are located below the feeder, 12 on each side.) Two separate discharges are also available for bulk vehicles. Hence feed can be delivered to 28 locations — the 24 pens, the full two

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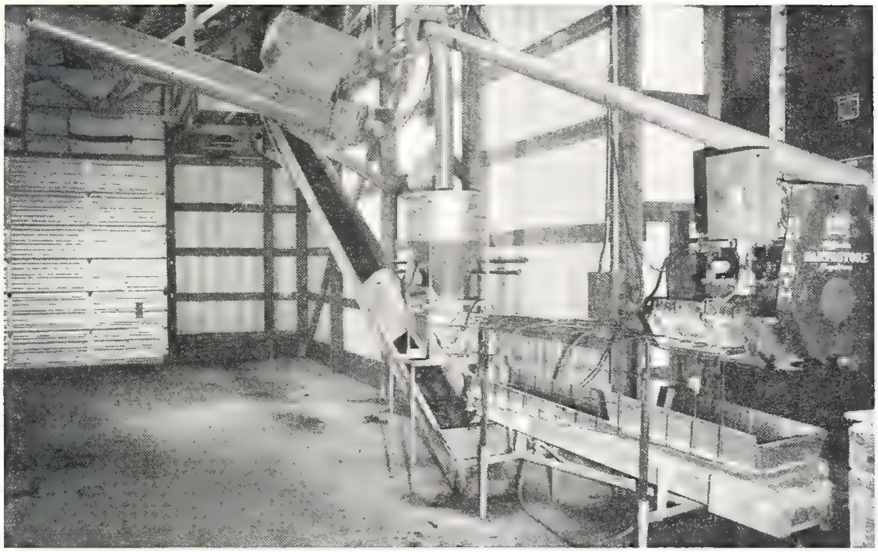
An overhead conveyor belt transports a complete ration from the feed storage and processing area at right to the confinement building at left. (Fig. 1)



Inside the processing building, with Harvestore at right, the concentrate dispensers next, and then the elevating conveyor. The bottom unloader discharges silage from the Harvestore onto an electronic scale. The rate of silage flow regulates the discharge rate of the concentrate dispensers. The mixture is elevated to the overhead conveyor belt, which crosses to the sheep building. If the conveyor belt is reversed, the auger on the upper left can load the material onto a wagon. (Fig. 2)

Feed drops onto a belt distributor in the confinement building. A brush take-off unit, oscillating between selected "stops," discharges feed into mangers beneath the distributor belt. Feed can be discharged to either side of the distributor belt. (Fig. 3)

sides of the feeder, and two separate discharges for bulk vehicles. It can also be delivered to some of the pens on either side of the feeder.

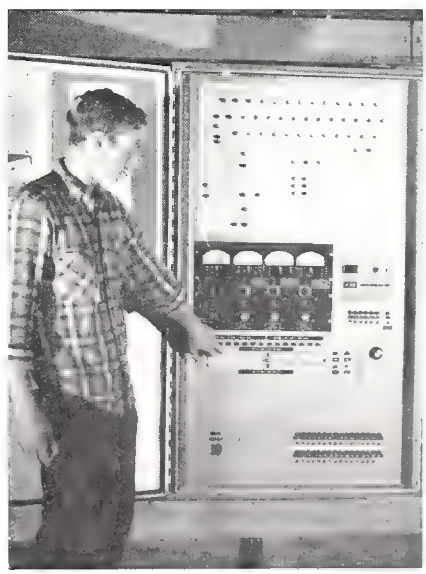
The number of discharge locations presents no problem for the programmable sequence controller, and it can be expanded to form a larger control system when necessary.

At present, an analog concentrate proportioning control is used because the initial cost was lower than for digital control. It is expected that the capability of the computer-based relay control system will increase to include simple 4-function mathematics. Relative costs of the control system and the digital controllers for feed-dispensing motors will decrease. With decreased costs and increased capability, digital control of ration blending will be preferred to analog control.

The instruction program for the programmable sequence relay controller has 505 steps or words of memory (a word is 16 binary bits in this system). Time delays and counters are included in the program. The last 18 words of instruction create a timer which times the system operation in 1/10-second increments up to 100,000 hours.

Advantages summarized

The programmable sequence controller is reliable, easy to use and maintain, flexible, and relatively inexpensive. The use of standard components gives assurance that replacement parts will be readily available when needed. Since the components are plug-in units, servicing is simple. The construction is such that the user does not have to know electronics to service the system. It represents a real breakthrough in farmstead control systems.



Control panel. For automatic operation, the operator selects the pen (or pens) to be fed, chooses ration components and proportions, sets the amount of forage to be delivered, resets the electronic scale counter, and presses the start button. After delivering the right amount of feed, the system will shut itself off. For manual operation, the operator turns any circuit on or off to move material as desired. Manual operation by-passes all sequencer elements. (Fig. 4)

Methane Production From Cattle Wastes

Manure fermentation starts rapidly and continues steadily if the reactor is operated at a temperature of about 140° F.

V. H. VAREL, H. R. ISAACSON, R. A. FROBISH, and M. P. BRYANT

Microbial decomposition of organic matter is a very important process in nature. It returns elements to the soil and air, where they can be used for new plant growth.

Complex mixtures of interacting microbial species are involved in decomposition. They utilize many kinds of organic compounds and other nutrients from plant and animal materials for growth, and excrete various metabolic end-products.

Products of decomposition

In natural systems where oxygen is available — that is, under aerobic conditions — the main microbial waste products are carbon dioxide and water. However, many accumulations of organic matter — for example, sediments from natural waters — cannot be penetrated by air. Conditions are then said to be anaerobic. Many diverse species of bacteria are called anaerobes because they grow and carry out their metabolism of organic matter where oxygen is not available.

When organic matter is digested anaerobically, complex organic carbon compounds such as cellulose, proteins, and fats are finally degraded to two of the simplest carbon compounds. These are carbon dioxide, the most oxidized one-carbon compound; and methane, the most reduced one-carbon compound.

If organic materials pass through an anaerobic system relatively fast (one to three days), volatile fatty acids such as acetic acid accumulate. This occurs in microbial ecosystems such as the rumen of cattle and sheep, and the large bowel of most animals. The microbially produced acid serves as the main source of energy for ruminants.

If materials are kept in the ecosystem for a longer time, then the acids are degraded to carbon dioxide and methane, with methane usually making up 50 percent or more of the final products. Methane is a very valuable chemical because it contains a large amount of energy in a form very useful to man. Natural gas is mostly methane.

Reasons for study

With the diminishing supply of natural gas and the huge amount of cattle waste, interest has recently been focused on the practicability of producing methane from the waste by bacterial fermentation. The solid waste produced annually by farm animals in the United States is estimated at about 2 billion tons. About half of it is generated by intensive animal production systems such as large feedlots, creating serious problems of disposal, odor control, and prevention of stream pollution. Bacterial conversion of this waste would offer partial solutions to these problems as well as supplement our supply of natural gas.

With these potential benefits in mind, we have been conducting research on the microbiology and biological potential of methane production from cattle wastes.

Studies at high temperatures

In setting up our experiments, we utilized the results of research done by John Pfeffer, professor of sanitary engineering at the University of Illinois. He had found that biological methane production from municipal organic refuse, mainly paper products, is most rapid at thermophilic temperature — that is, about 140°F. This suggests that methane production may be most economical at this temperature. Because of the rapid biological activity, reactors could be smaller than previously visualized, with a resultant lowering of capital costs as well as other benefits.

Initially we studied the fermentation of cattle wastes in small, 3-liter reactors. We found that the complex of bacterial species necessary for fermentation at 140°F. was present in the fresh cattle manure. With proper daily loading, mixing, and control of acid, a vigorous fermentation was established within about 12 days after start-up. This is important because it means that time-consuming practices of start-up and expensive means of maintaining established cultures of the needed bacteria will not be necessary.

Once established, and with daily feeding, the fermentation of feedlot waste was quite stable within a temperature range of 130° to 140°F. and a range of 3 to 15 days in retention time for the reactor contents. A retention time of 3 days means that

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one-third of the volume of the reactor contents is replaced each day; with a 15-day retention time, one-fifteenth is replaced.

Methane was produced most rapidly at about 140°F.; the bacteria did not adapt well to growth at 149°F. The gas produced at 140°F. has a relatively constant methane content of 54 to 58 percent, the rest being chiefly carbon dioxide.

Although pH or acidity has to be controlled when methane is produced from such materials as municipal refuse, this is not necessary for production of methane from animal wastes. The bacteria generate large amounts of ammonia, and this very effectively neutralizes the acid that the bacteria produce in the livestock wastes.

Efficiency of production

Reactors were established at different retention times (3, 6, 9, and 12 days) with a relatively low concentration of waste organic matter in water. Experiments were then done to measure the efficiency of methane production with increasing concentrations of waste. These experiments were necessary to determine the optimum conditions for growth, digestion of the waste, and methane production by the bacteria.

We found that methane production efficiencies, based on volume produced per unit of weight of organic matter fed, were progressively lower in the reactors maintained at the shorter retention times. With organic matter of about 8 to 10 percent in the feeds, the average production of methane per day per gram of organic matter fed to the reactors was as follows:

Retention time, days	*Methane, liters*
3	0.28
6	0.33
9	0.36
12	0.38

These values for methane production were equivalent to the destruction of about 38 percent of the organic matter for the 3-day retention time; 44 percent for the 6-day time; 48 percent for the 9-day time; and 50 percent for the 12-day time. As expected, the shorter the retention time, the lower was the destruction or digestion of the waste organic matter.

Another measure of the efficiency of methane production is the volume of methane produced daily per unit of reactor volume. On this basis, efficiency was greatest in reactors receiving about 8 percent organic matter and set at the 3-day retention time. Production was about 4.5 liters of methane per day per liter of reactor volume. This is the most rapid rate of methane production from a natural substrate that we have detected after extensive review of the scientific literature. It indicates that the rate of methanogenesis from feedlot cattle wastes is greater than in many other waste materials, and may be more economical than previously supposed.

Dairy cattle waste less useful

According to studies now in progress, wastes from dairy cattle are not as efficiently converted into methane as those from feedlot cattle. This is due to the greater proportion of forages in the dairy cow's rations.

Forages are high in lignins, a group of plant chemicals that are biologically degradable only at a very slow rate under aerobic conditions and hardly at all under the anaerobic conditions required for methane production. Lignins are closely associated with cellulosic materials and hinder the digestion of these materials by bacteria. A major problem in increasing the efficiency of methane production from dairy cattle wastes, as well as from other organic wastes, is to remove the plant lignins from the cellulosic materials.

Possible additional values of fermentation

Because cattle wastes are high in ammonia and other minerals, feedlot wastes can be fermented in combination with materials such as municipal refuse, which are deficient in the minerals necessary for bacterial growth.

Alternatively, because of lowered organic matter, the effluent should be more valuable as a fertilizer than the original feedlot waste. It is known that little nitrogen is lost from the reactors during methane production, and our studies indicate that most of the nitrogen is passed out in the effluent as microbial cells or as ammonia. For example, when the reactor was set at a medium loading rate, the effluent contained 1.45 percent crude protein, of which 47 percent was ammonia nitrogen and 32 percent, bacterial nitrogen. (The loading rate was 0.74 pound per cubic foot of reactor volume per day, with 7 percent organic matter in the feed and a 6-day retention time.)

Another possible use of the effluent is to remove the bacterial cells before disposing of the fluids. Since protein makes up 50 to 60 percent of the dry matter in these cells, they could be fed to nonruminant livestock as a protein source. The use of thermophilic temperatures helps to alleviate possible health problems in that most pathogenic organisms should be killed after a short exposure to 140°F.

Continuing studies

In association with Professor Donald Bray, we are planning studies on the separation of bacterial cells from effluents and their evaluation as protein sources for chicks.

With the cooperation of Professor Carl Davis, we are continuing our studies on the kinetics of bacterial growth. We are also studying chemical composition of different organic materials in relationship to the efficiency of methane production. We hope to establish equations using chemical composition to predict the efficiency of methanogenesis from a wide variety of organic wastes and crops.

These studies should indicate relevant biological values and efficiencies. If large-scale facilities fed chemically similar materials do not operate with similar efficiencies, then one can assume that engineering problems, rather than biological potential, are involved.

Dehumidifiers for Drying Grain

E. D. RODDA

In the future it may be possible to dry grain with air that has been dehumidified rather than heated. At present grain is normally dried by blowing heated air through a layer of the moist grain. The air is heated to lower its relative humidity, thus increasing its ability to hold water as it evaporates from the grain. Addition of heat also increases the rate at which moisture moves from the grain, but the major benefit is the reduction in relative humidity.

Relative humidity can also be lowered by passing moist, unheated air over a layer of drying material, or desiccant. Common desiccants are granular silica gel and activated alumina in ball form. These materials are adsorbents — that is, they attract and hold water on their surfaces. Adsorbents may be reactivated (regenerated) by heating them to drive off the adsorbed moisture.

Adsorbent dehumidification is widely used in industrial processes requiring dry environments. An agricultural application now under study is the use of dehumidification and heat to dry seed corn. The drying air can not be too hot, or germination will be reduced. Use of a desiccant dehumidifier in conjunction with heat reduces the moisture content of the drying air and thus speeds up the drying process for a given temperature and air flow. In research at Urbana, we are also looking at the merits of drying soybeans without heat, using only dehumidified air.

How dehumidifiers work

Solid adsorption dehumidifiers may have stationary or rotating desiccant beds. Stationary units may have single beds which must be shut down and reactivated periodically, or they may have dual beds, one used while the other is being regenerated. A typical dual-bed unit is diagrammed in Figure 1. Many variations are possible, depending on the air volume and degree of dryness desired. Reactivation can be by electricity, steam, or gas.

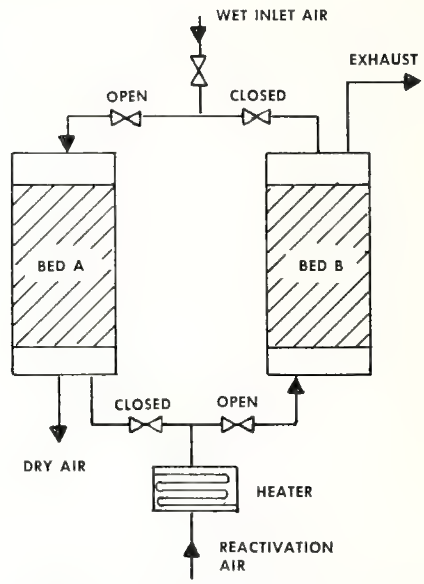
When water vapor is adsorbed on a desiccant such as silica gel, heat is liberated equivalent to the latent heat of vaporization, plus an additional amount of heat known as the "heat of wetting." The sum of the latent heat and the heat of wetting is called the "heat of adsorption."

The heat of wetting "activated" silica gel is 400 Btu per pound of water adsorbed. This decreases to zero as the gel becomes saturated. The average heat of wetting for beds attaining a useful capacity of 10 to 15 percent is 325 Btu per pound of water adsorbed. This plus the latent heat of the water will be about 1,400 Btu per pound of water adsorbed. The resulting temperature rise of the dehydrated air may be estimated as 10°F. multiplied by the grains of water adsorbed per cubic foot of air. Some additional rise also occurs because of residual heat from reactivation.

At 100 percent relative humidity, silica gel can adsorb an amount of water equal to approximately 40 percent of its dry weight. This capacity for water adsorption cannot generally be realized in practice because of the time required to reach equilibrium as the material approaches saturation. Useful capacities for atmospheric dehumidification are more likely to range from 5 to 15 percent. The useful capacity is affected by a long list of factors: bed depth, contact time and air velocity, temperature, inlet humidity, exit dew point, size and shape of desiccant particles, pressure, and reactivation method.

Rotating bed dehumidifiers

Commercial atmospheric dehumidifiers often have rotating beds which are continuously regenerated.



Typical dual-bed dehumidifier. (Fig. 1)

Two types are discussed here: (1) a rotating vertical drum and (2) a single or multiple rotating horizontal disk. Either type can be equipped for humidistat control.

Typical air flow for a vertical drum type unit is diagrammed in Figure 2. The desiccant is in a cylindrical structure formed from perforated metal, providing a vertical bed 1 to 2 inches thick. Rotating about its vertical axis, the cylinder cycles the desiccant alternately through the wet process air stream and the heated reactivation air stream. The two air streams are separated by metal partitions built into the machine housing. Internal pressure should be held so that any leakage occurs toward the reactivation side.

A rotating horizontal bed type unit is diagrammed in Figure 3. Circular beds containing the desiccant are continuously rotated through two separate, sealed compartments. In

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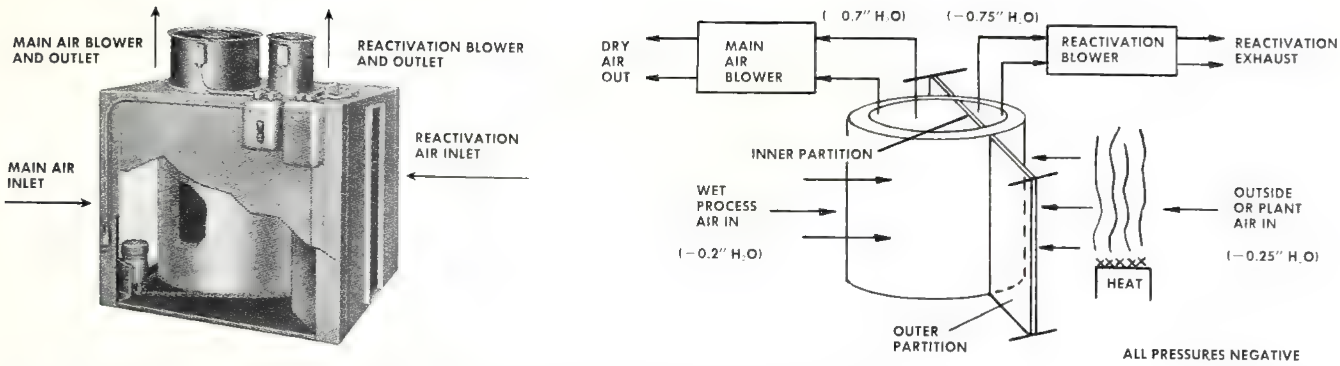
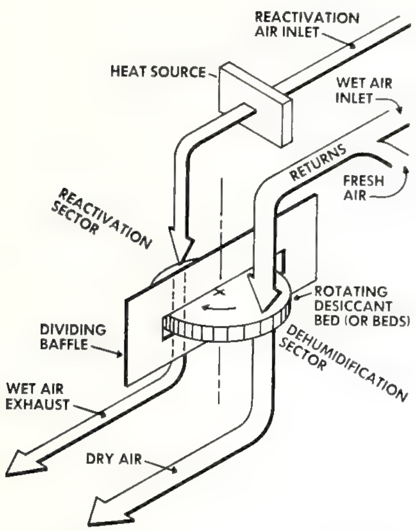
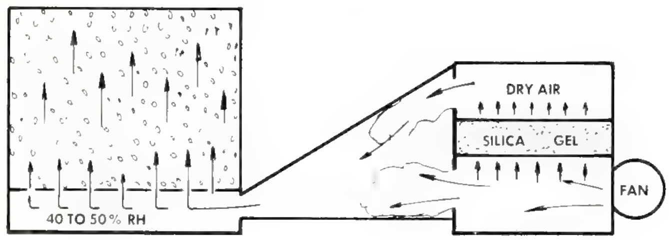


Rotating vertical drum-type dehumidifier. The desiccant is alternately cycled through two air streams. **(Fig. 2)**



Rotating horizontal-bed unit. **(Fig. 3)**



Small laboratory dryer. **(Fig. 4)**

one compartment, the desiccant dehumidifies the air; in the other, heated air regenerates the desiccant beds. The beds are covered on each side with perforated steel sheet to permit controlled passage of air in drying and reactivation.

Laboratory dryer

The small dryer shown in Figure 4 was constructed for laboratory studies of soybean drying rate, air flow requirements, heat for desiccant regeneration, and soybean quality. The desiccant bed was removed for regeneration and replaced with a fresh bed for continuous operation.

Relative humidity of the drying air was kept between 40 and 50 percent by blending moist air with dry air from the silica gel bed. Drying air with a relative humidity below 40 percent causes excessive seed coat cracking. Soybeans will dry to about 9 percent moisture content when the relative humidity of the air is 50 percent. Equilibrium moisture contents of soybeans at various temperatures and relative humidities are given in Table 1.

Research results

Soybeans dried with air having a controlled relative humidity (between 40 and 50 percent) exhibited no drying damage such as cracked seed coats. Results compare to those from drying with natural air under favorable weather conditions.

When two 40-bushel lots were dried in November with an air flow of 5 cfm per bushel, 4 days were required to reduce the average moisture content from 21.5 percent to 13 percent. In a lot dried in early April under favorable weather, moisture content was reduced from 16.5 percent to 10 percent with 75 hours of intermittent operation. Another lot dried in March required 138 hours (5.75 days) of intermittent operation during a period of 16 days to reduce the average moisture content from a 22-24 percent range to 9.5 percent.

The energy required for reactivation of the silica gel bed in the small laboratory design corresponded to accepted values. The laboratory dryer has now been replaced with a commercial rotating bed unit which will be better suited for grain drying because of the large amounts of moisture that must be removed. Work is continuing on the evaluation of total energy requirements and on designs for integrating the dehumidifier into a drying system.

Table 1. — Equilibrium Percent Moisture Content of Soybeans at Various Temperatures and Relative Humidities

Air temp., degrees F.	Relative humidity, pct.								
	50	55	60	65	70	75	80	85	90
	Moisture content, pct.								
30	8.9	9.8	10.8	12.1	13.2	15.1	17.1	20.1	22.9
40	8.7	9.6	10.5	11.8	13.0	14.9	16.8	19.7	22.5
50	8.5	9.4	10.2	11.5	12.8	14.7	16.5	19.3	22.1
60	8.3	9.2	10.0	11.3	12.6	14.5	16.3	19.0	21.7

Aging and Respiration: *Lessons From Two Fungi*

DAVID GOTTLIEB

Most of us are only too aware of the aging process in human beings and animals. However, not many realize that this process occurs in all matter, living and nonliving. Common to all aging is a change from a highly organized to a less organized structure until theoretically a disorganized or random state is reached. Energy is required for the organized state; as we approach the random state, the need for energy declines.

Fungi and people

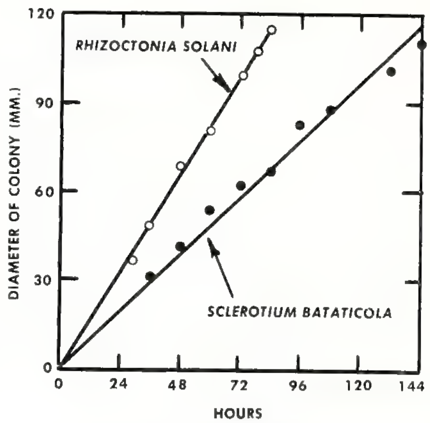
Why should a plant pathologist be professionally interested in this, to some, rather painful subject? The fact is that many plant disease processes are related to the pathogen's age. For example, the age of fungus spores might determine whether they can infect the host plant. Similarly, the age of a soil-borne fungus can influence its ability to infest the soil, and so affect the amount of root rot.

For broader purposes, fungi can act as model systems on which to study the biochemical processes involved in aging. Fungi resemble animals and plants much more than do bacteria or blue-green algae. If one studies the proper fungi, one can measure the magnitude of cell changes that accompany increasing age without confusing these changes with the ones that are related to the developmental stages of an organism, such as reproduction.

Concepts of aging

Aging can be defined in many ways, but it is most commonly categorized as either chronological or physiological. Our studies used the chronological definition, in which the baseline is the length of time a cell or group of cells has existed. The physiological definition refers age to the functional ability of the cells, such as the capacity for using oxygen, making protein, or reproducing.

David Gottlieb is professor of plant pathology.

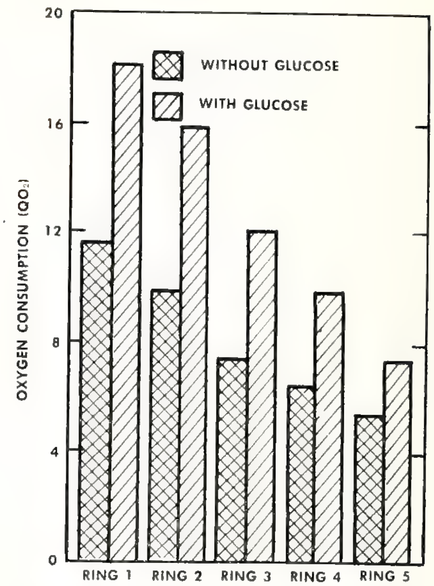


Growth curves of ***Rhizoctonia solani*** and ***Sclerotium bataticola.*** (Fig. 1)

There are many ideas as to the causes of aging. One is that the cellular machinery gradually wears out. Another is that poisons accumulate in the cell, either because the cell gradually loses its ability to excrete them, or because more poisons are formed with increasing age.

Still another theory attributes aging to the increasing exposure, over time, of cells and tissues to injurious rays in the atmosphere. This exposure might directly cause functional changes. Or it might operate indirectly by producing genetic aberrations that cause the gradual accumulation of toxic products or the decreased activity of normal functions.

According to another theory, aging is genetically controlled, and the code or message in the genes determines the aging process, the length of time before a cell wears out, or the number of doublings or divisions of the somatic cells.



Relationship between age of *Sclerotium bataticola* and oxygen consumption with and without glucose. (Ring 1 is the youngest; ring 5, the oldest.) (Fig. 2)

Two fungi studied

Two pathogenic fungi, *Rhizoctonia solani* and *Sclerotium bataticola,* were chosen for our studies because they formed nonsporulating, vegetative colonies that grew at a moderate, uniform rate during the experiments (Fig. 1). In such systems, the nutritional, toxic, and other environmental factors would not cause any of the age-dependent reactions that we measured. We would thus detect only those changes taking place with time, and would especially look for changes very early in the life of a cell.

When grown in liquid cultures, the organisms formed uniform round colonies. These could be cut with a die having circular knives at various distances from the center. Such cuts divided cells according to age, with the oldest in the center sections and the youngest in the peripheral sections.

Early results

No changes in the cellular structure of either fungus were detected

by the light microscope or the electron microscope. Furthermore, the young and old cells did not differ in proportions of viable cells, as measured by vital stains and tetrazolium dye reactions. Finally, the age of the cells did not consistently affect permeability, which was measured by the uptake and leakage of radioactive metabolites.

The percentages of several biochemicals did vary with age. Common to both species was an age-related decrease in ergosterol, protein, ribonucleic acid (RNA), and deoxyribonucleic acid (DNA). These results were guides pointing to areas for more basic study.

Another change that occurred in both fungi as they aged was a marked decrease in the oxygen consumption of whole cells (Fig. 2). This decrease was apparent both in the respiration of internally stored carbon compounds and in the consumption of glucose added to the cell suspension. It seemed obvious that the phenomenon was caused by deleterious changes in one or more of the enzymes involved in the respiratory systems.

But which enzymes were responsible? Using oxygen consumption as the primary measure of activity, we studied 31 enzymes that are involved in or are ancillary to respiration. These studies failed to pinpoint any enzymes that consistently decreased or increased their activity in both fungi.

We believed that, to be meaningful in the aging process, age-dependent changes should be common to our two organisms, at least. One could, of course, argue that age-dependent changes in respiration need not be the same in different organisms. The important fact is that some change, interfering with continued optimum growth or activity, does occur. This site of malfunction, if it indeed is such, could be equally important to the aging process if it occurred at any one of several places in the respiratory pathways. But, for the moment, we held that the more universal a phenomenon, the more important it might be in aging.

An idea appears

Our inability to pinpoint the particular enzyme responsible for the decreased respiration puzzled us for many months, for surely some enzyme did hold the key to decreased respiration. By chance one day, while we were measuring the respiration of other fungi for another purpose, an idea developed of which we should previously have been aware. We knew, of course, that enzyme activity requires at least two parts of the enzyme, the protein portion (apoenzyme) and a coenzyme or cofactor. The cofactors are routinely added to get optimum respiration, which is what we were doing in our experiments. We suddenly realized that, while this addition allowed us to better detect changes due to malfunctions of the apoenzyme, it would mask any deficiency in the cofactors that might occur with age.

With this realization we quickly turned to studying concentrations of the coenzymes and cofactors in whole cells of *R. solani* and *S. bataticola.*

Of several mineral cofactors measured, only iron was consistently low in both fungi. A number of organic cofactors decreased with age. In *R. solani,* both nicotinamide adenine dinucleotide (NAD) and its reduced form decreased by 40 to 50 percent when their concentrations were calculated on dry weight, protein, or DNA basis. Nicotinamide adenine dinucleotide phosphate (NADP) and its reduced analog behaved in much the same way. Adenosine mono-, di-, and triphosphate contents also declined. Flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD) were most drastically reduced, 70 to 90 percent in old cells. Similar results occurred with *S. baticola.*

Old cells respire like young ones

The decreases of various cofactors in the older cells suggested that the decline in respiration and in enzyme activities might be caused by a deficiency of cofactors. Ideally, we should have been able to feed the proper cofactors to the cells, thereby stimulating old cells to respire like young ones. Unfortunately, when we tried this, difficulties arose because of the cofactors' poor entrance into the cells.

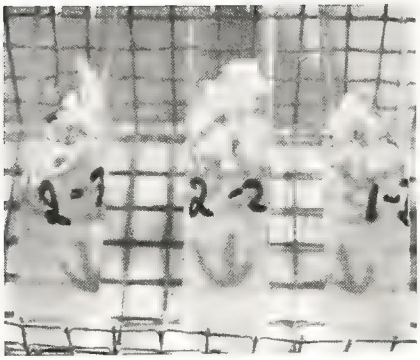
The next best experiment, however, was successful. For this, cell-free preparations were made by grinding the cells of the fungi to break down cell walls and membranes. Such preparations, although technically dead, could still respire and consume oxygen. Their advantage was that there were now no barriers against the cofactors, and any one that we might add would be available to the apoenzyme.

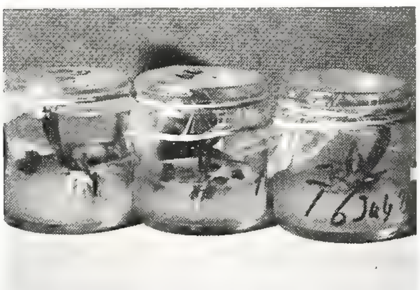
Mixtures of cofactors that had decreased with age were added at several concentrations to cell-free preparations of *R. solani* and *S. bataticola* made both from young and from old cells. Oxygen consumption was then measured. After receiving given levels of certain cofactors, old cells of both fungi began consuming as much oxygen as young cells. Higher levels of cofactors were toxic to the preparations from young cells.

Studies with individual cofactors showed that all but the two flavins, FMN and FAD, caused some stimulation. Apparently even highly reduced concentrations of these compounds in old cells were sufficient to maintain respiration.

Future plans

Our future plans are to add coenzymes to whole cells and determine whether the limited respiration is indeed due to the reduction in cofactors. If an age-dependent decrease of some cofactors does reduce respiration, we will seek the reason. For example, are the reduced levels of cofactors in older cells due to the cells' inability to make these cofactors, or to the breakdown of these chemicals with age? Then there is the important question as to whether aging in animals can be related to an insufficiency of growth factors. After all, when we add vitamins to our diets we are ingesting cofactors or coenzymes, and it might be that in this the human being and the fungus are similar.





Propagation of tall bearded iris by tissue culture techniques. (***Top***) Best callus is forming on thin flower stem slices in center tube with 2.5 milligrams of NAA and 0.5 milligram of kinetin per liter. (***Center***) Plantlets forming on edges of transferred callus in jars. (***Bottom***) Plant of Stepping Out variety flowering true to type. (Fig. 1)

Tissue Culture Techniques Speed Plant Propagation

MARTIN M. MEYER, JR.

Many new horticultural plant varieties are slow to appear in the marketplace simply because they must be reproduced by division, an often lengthy process starting with a single, original plant. According to results of recent research, however, tissue culture techniques of propagation can speed growth and thus shorten the time interval between development and marketing of a new variety.

The technical details of tissue culture techniques of propagation are complicated, but the basic principles are easy to understand. Small pieces of tissue are excised from the plant and placed in a test tube or other artificial environment. The tissue then is induced to form small shoots, plantlets, or masses of undifferentiated cells called callus tissue. If callus is formed, it then is induced to make small shoots or plantlets. The shoots that are produced by either of these methods are rooted just as small, ordinary cuttings. A similar procedure using an embryo excised from a seed can speed germination of plant seeds that are difficult or impossible to germinate by standard methods.

Several terms have been used to describe these techniques of speeding growth and reproduction. Since the small pieces of excised tissue have to be raised under sterile conditions on a medium containing organic materials, the terms micropropagation and sterile culture often are used. If the explant is an apical meristem, the method can be referred to as meristem propagation or meristemming. The term tissue culture propagation often is used when callus or undifferentiated tissue is the first product. When an excised plant embryo is used, the process is called embryo culture.

The Department of Horticulture at the University of Illinois at Urbana-Champaign is becoming a center for research on tissue culture propagation of hardy herbaceous and woody perennials. Among the species studied have been the iris, daylily, and peony.

Studies with iris

Plant breeders are developing many tall bearded *Iris* varieties, some of which have spectacular colors. However, a new iris cultivar must be propagated asexually and a return of two plants plus the original per year is considered good. This means a delay of several years before the grower has the quantities of a new variety necessary for commercial release.

Explants from meristems, rhizomes, and flower stems were used at the University of Illinois in experimental efforts to reduce this time interval. Meristem tissue grew and formed plants in the light, but the plants did not proliferate readily. Rhizome tissue turned brown and died.

Flower stem tissue was cut into 1- to 2-millimeter slices and cultured in the dark upside down on a modified Murashige-Skoog (M-S) high-salt medium supplemented with hormones. The hormone requirement was determined by trying all possible combinations of naphthaleneacetic acid (NAA) at 0.5, 2.5, and 10 milligrams (mg.) per liter and kinetin at 0.1, 0.5, and 2.5 mg. per liter. Considerable callus was produced on the flower stem tissue in 6 to 12 weeks

Martin M. Meyer, Jr., is associate professor of nursery management.

when a medium containing 2.5 mg. per liter NAA and 0.5 mg. per liter kinetin was used.

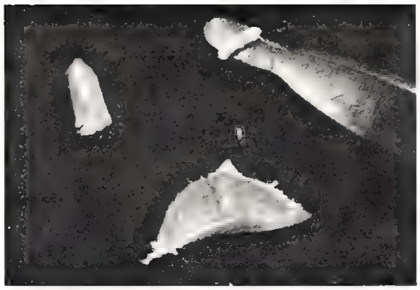
The callus then was sectioned and placed in the light on a medium with NAA at 0.5 mg. per liter and kinetin at 0.1 mg. per liter. Plantlets began growing on the periphery of the callus in 6 to 24 weeks. When large enough, the plantlets were transferred to a soil medium. The varieties Glacier Gold, Stepping Out, and Rococco propagated in this manner have flowered and are true to type.

Studies with daylily

The *Hemerocallis,* or daylily, is losing its small-orange-or-yellow-flower image because of the many new varieties being developed. As with the iris, however, building enough stock for commercial release can take a number of years. Studies with the daylily similar to those conducted with the iris also have indicated that tissue culture techniques of propagation could reduce this time interval.

Callus tissue was formed when slices of flower stem tissue were placed on an M-S medium containing 10 mg. per liter NAA and 0.1 mg. per liter kinetin. The callus masses were sectioned and moved to the light on a medium with 0.5 mg. per liter NAA and 0.1 mg. per liter kinetin. Plants formed on 10 to 25 percent of these callus masses in 6 to 24 weeks. The plants then were transferred to a soil medium and grown to flowering. The varieties Roy's Yellow, Chicago Sunrise, and Chicago Royal reproduced in this manner are true to type and retain the tetraploid condition desirable in *Hemerocallis.*

Roy's Yellow daylily propagated with tissue culture technique. (Fig. 2)



Embryo culture of peony in vitro. (*Top left*) Excising rudimentary embryo from seed endosperm. (*Right*) Peony embryo excised and grown 16 weeks in light at 27°C. on right, and one grown 7 weeks at 26°C., 5 weeks at 1°C., and 4 weeks at 26°C. on left. (*Lower left*) Seedling has been transplanted to pot. (Fig. 3)

Studies with peony

Seeds of the *Paeonia,* or peony, have an immature embryo and a dormant epicotyl and thus the plant has a long breeding cycle. It normally takes one year and sometimes two or three for peony seeds to germinate. It then takes several years for the seedlings to flower. Although propagating peony plants from small pieces of plant tissue is difficult, the embryo culture method can be used to shorten the plant's breeding cycle.

In studies at the University of Illinois, the embryo was excised from the seed and placed on a modified Linsmaier-Skoog medium. The embryo enlarged rapidly and in 6 weeks was mature with a root 3 inches long. After the mature embryo was given 4 to 6 weeks at 1°C. (34°F.) to satisfy epicotyl dormancy, germination took place immediately at 27°C. (80° F.). The plants then were transferred to pots and pushed for spring planting. This technique could eliminate one to two years in the breeding cycle and allow for more rapid development of new peony varieties.

Into the catalogs

In all these studies, tissue culture techniques speeded plant growth. In addition, the number of plants produced in a given period of time was much greater when tissue culture techniques were used than when division methods were relied upon. Because of this continuing research, new plant varieties are likely to be available to the public much sooner after they are developed than they are at present.

Effects of Dietary Caffeine on the Reproductive Performance of Chickens

R. L. AX and J. R. LODGE

Every year people consume enormous amounts of caffeine in coffee alone, to say nothing of tea and a number of carbonated beverages. We all know some of the effects, such as sleeplessness, resulting from too much caffeine. Various other effects of caffeine in different organisms have also been noted in research at the University of Illinois and elsewhere.

In some species caffeine has been reported to cause mutations and teratogenesis, or the production of deformed offspring. Research with mammals suggests that caffeine is harmful to embryonic tissues and causes abnormal spermatogenesis, or sperm formation, in males. This can be attributed to the fact that caffeine disrupts cell divisions by inhibiting DNA replication mechanisms.

To learn more about the effects of caffeine on fertility, embryonic mortality, and spermatogenesis, we recently initiated a study using chickens as the experimental animals.

Table 1. — Fertility and Embryonic Loss in Eggs From Pullets Fed Caffeine or the Standard Ration; Eggs Collected for 14 Days Following a Single Insemination

Ration	No. of eggs	No. of fertile eggs	Pct. fertile eggs	No. of eggs incubated	No. of dead embryos	Pct. dead embryos[a]
Control	1,127	506	44.9	116	6	5.2
Caffeine 0.05 pct.	450	188	41.7	188	31	16.5*
Caffeine 0.1 pct.	1,187	574	48.3	157	60	38.2*

[a] Percentage of fertile eggs incubated.
* Difference from control is statistically significant ($p < 0.005$).

Table 2. — Fertility and Embryonic Loss in Eggs Collected From Pullets for 14 Days After a Single Insemination of Semen From Roosters Fed Caffeine for Varying Times

Days after addition of caffeine to diet	No. of eggs	No. of fertile eggs	Pct. fertile eggs	No. of dead embryos	Pct. dead embryos[a]
0	991	306	30.8	23	7.5
7	549	184	33.5	10	5.4
14	634	23	3.3*	4	17.4
35 (caffeine removed for 28 days)	361	112	31.0	10	8.9

[a] Percentage of fertile eggs incubated.
* Difference from control is statistically significant ($p < 0.005$).

Effects on females

White Leghorn pullets were fed either 0.1 or 0.05 percent caffeine in their laying rations ad libitum and were compared to a control group that received no caffeine. The average fertility values of incubated eggs from the three groups of pullets did not differ significantly, but embryonic mortality increased as dietary caffeine levels were raised. At both levels of caffeine, embryonic mortality was significantly higher than for the control group (Table 1).

Effects on males

A group of roosters were fed 0.1 percent dietary caffeine in their normal ration ad libitum while a control group received no caffeine. Pullets receiving the standard laying ration without caffeine were inseminated with semen collected from both groups of roosters just before caffeine was added to the experimental diet, and 7 and 14 days later. For 14 days after each insemination, eggs were collected daily and were incubated.

Semen was collected twice a week and examined for volume, sperm concentration, and sperm motility. At various times during the experiment roosters were sacrificed and histological sections of testicular tissue were prepared.

Fertility values for eggs from the pullets not receiving caffeine and inseminated with semen collected 0, 7, and 14 days after the addition of dietary caffeine were 30.8, 33.5, and 3.3 percent, respectively. The last fertility value was significantly lower than the other two values.

In embryos resulting from sperm collected 14 days after dietary caffeine addition, percent mortality was more than twice as high as in embryos resulting from the other two inseminations (Table 2). Even so, the difference was not statistically

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R. L. Ax is currently a graduate student in animal science; J. R. Lodge is professor of dairy science. Mr. Ax conducted these experiments for his M.S. thesis in dairy science. The authors acknowledge the aid of R. J. Collier, graduate student in dairy science, and D. J. Bray, professor of animal science.

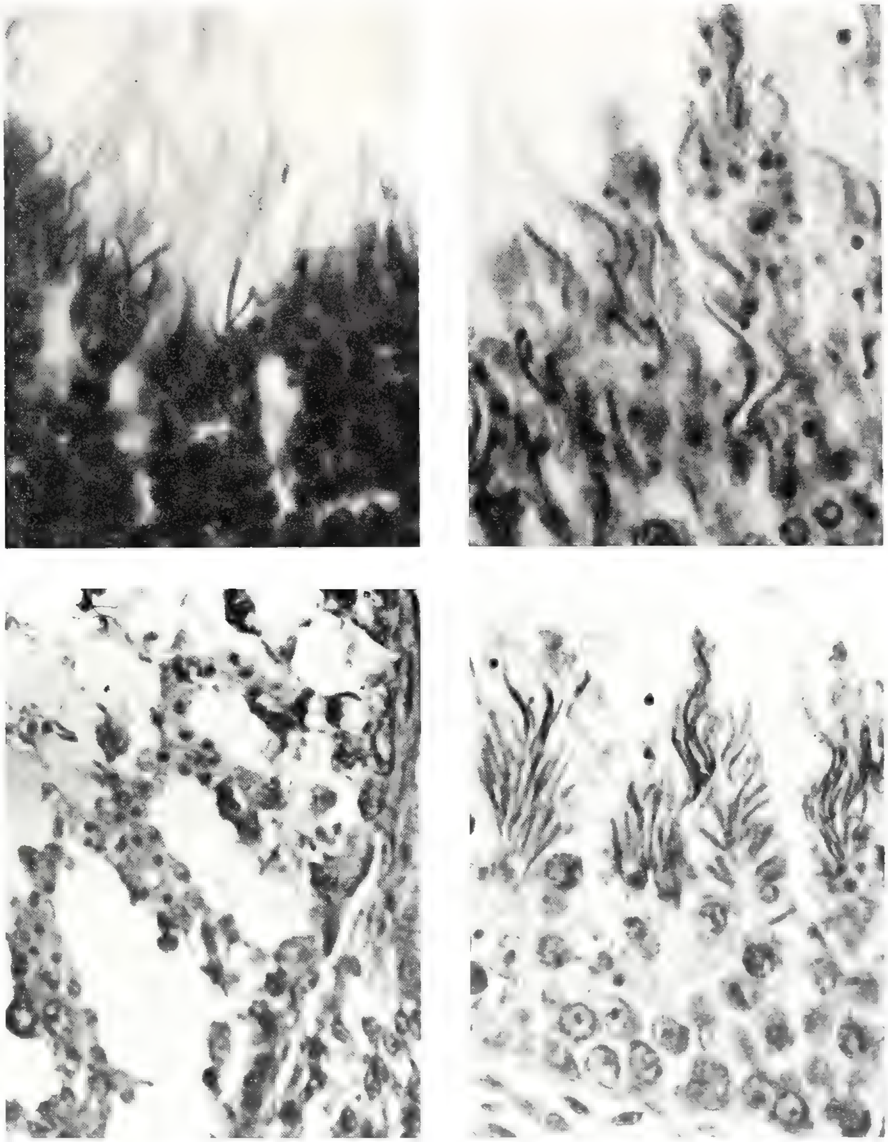
Table 3. — Effects of 0.1 Percent Dietary Caffeine on Rooster Spermatogenesis

No. of days fed caffeine	Semen volume, ml. (8 roosters)	Sperm concentration per ml. of semen
−3	5.6	5.9×10^9
0[a]	5.8	5.8×10^9
7	6.2	4.8×10^9
14	6.9	5.9×10^9
23	2.1	43.8×10^6
29	2.1	32.0×10^6
30[b]	0	0
63[c]	0	0

Caffeine removed from 2 roosters on day 35

Days after caffeine withdrawal	Semen volume, ml. (2 roosters)	Sperm concentration per ml. of semen
2	0	0
9	0	0
11	1.0	10.0×10^6
17	1.4	3.3×10^9
21	1.3	5.8×10^9
23	1.2	6.4×10^9
28[d]	1.2	6.4×10^9

[a] Caffeine started after collection.
[b] Four roosters sacrificed on day 30.
[c] Two roosters sacrificed on day 63.
[d] Two roosters sacrificed on day 28.



Testicular cross-sections from roosters on four diets: (*Top left*) Standard ration without caffeine. Spermatogonia, spermatocytes, and spermatids are attached to the Sertoli cells. (*Top right*) 0.1-percent caffeine for 31 days. This plate shows pyknotic nuclei sperm heads and few spermatocyte divisions. (*Lower left*) 0.1-percent caffeine for 63 days. Only Sertoli cells appear. (*Lower right*) 0.1-percent caffeine for 35 days and then the standard ration for 28 days. Spermatogenic activity has resumed but a few pyknotic nuclei remain. (Fig. 1)

significant because of the low number of fertile eggs produced when roosters had received caffeine for 14 days.

The decrease in fertility occurred before there was any reduction in sperm output (Table 3). All pullets were inseminated with 100×10^6 motile sperm, indicating that caffeine directly damaged the spermatozoa and reduced fertilizing capacity.

Between 17 and 21 days after caffeine was added to the diet, semen output and sperm concentration dropped markedly. After the roosters had received caffeine for 30 days, no semen could be collected at all. Semen could again be collected 11 days after caffeine was removed from the diet.

Histological sections of testes from the sacrificed roosters indicated that spermatogenesis was markedly disrupted by caffeine, but that the effects on spermatogenesis and fertility were reversible after caffeine was removed from the diet (Figs. 1-4).

The libido, or sex drive, was not impaired because roosters responded to manual stimulation and attempted to ejaculate during the 63 days that they were fed 0.1 percent caffeine.

Other research

In an experiment with another group of roosters, D. R. Hagen (a graduate research assistant in the Department of Animal Science) confirmed the effects of 0.1 percent dietary caffeine on spermatogenesis and spermatozoa output. However, a dietary level of 0.05 percent had no effect on spermatogenesis as determined by the number of spermatozoa collected.

Much additional research is needed to determine the exact mechanism of caffeine damage to various reproductive tissues. Research is being continued on the effect of caffeine on reproduction in laboratory animals.

FARM BUSINESS TRENDS

FARMLAND is the Illinois farmer's largest single cost or input item. Depending on its productivity and quality, it absorbs one-third to one-half of the gross value of his crop.

In the rental market, it is priced on an annual basis, with its net cost amounting to 20 to 40 percent of the crop. But land is a durable factor yielding a flow of products and services over time. Thus, in the ownership market, it is priced as a capital sum which, at any given time, represents the current worth of its expected future net incomes. The ownership price of farmland may range from 10 to 35 times its annual net rent, depending upon the rate of capitalization or rate of return required.

Average prices paid for Illinois farm real estate (land and buildings) in the last 25 years ranged from a low of $205 per acre in 1951 to a high of $1,184 on February 1, 1976. Most of this increase has come since 1972 (see chart). Farmland values doubled from 1951 to 1967. They doubled again from 1967 to 1975.

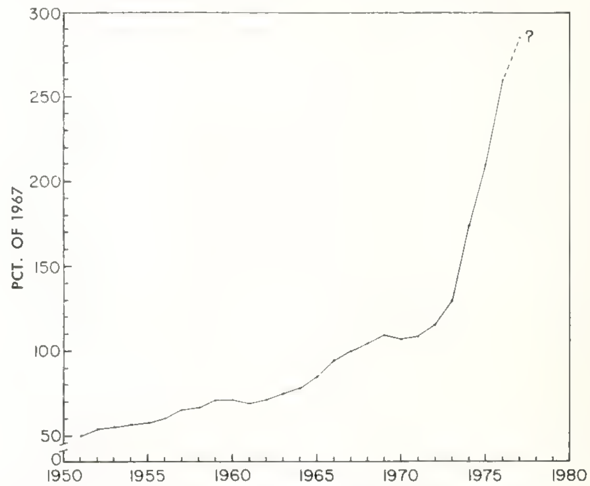
Farmland prices have been rising, almost without interruption but at varying rates, since the 1930's. The annual growth rate for most of this period was 5.0 to 5.5 percent on a compound basis. From 1972 to 1975 the average annual increase was 21.7 percent. Between March, 1975, and February, 1976, the increase was a record 24.4 percent.

Originating and supporting these rises in land values were unprecedented increases in net income to Illinois farmland. Average net rent received by crop-share landlords on grain farms with top-rated soils increased from about $32 per tillable acre in 1967 to a high of about $120 in 1974. Net rents since then will average about $100 per tillable acre on these farms.

If a prospective purchaser wants a current return of 5 percent on his money, then he could bid up to $2,000 an acre on $100 net rent land. If he would be satisfied with a 3 percent return, then he could bid up to $3,333 an acre. If he expects land to appreciate at an annual rate of at least 6 percent, then his combined 3 percent operating return and 6 percent capital gain could justify his borrowing money at 9 percent to invest in land.

The above example assumes that the buyer can meet the cash flows required for interest and principal payments. A 40-percent down payment on an 80-acre tract priced at $3,000 an acre would amount to $96,000. Interest alone on the unpaid balance would be $12,960, or $162 an acre. Most young farmers trying to pay for a set of modern machinery and equipment cannot meet these requirements. They become some of the tenants who collectively rent about 6 out of every 10 acres of Illinois farmland.

With net farm income leveling off and costs of land ownership, such as property taxes, continuing to rise, farmland prices are not likely to continue increasing at the rate observed since 1972. However, land values will probably continue on an upward course, possibly one that approximates the rate of inflation. — *Franklin J. Reiss, Extension Specialist, Land Economics*



Average acre value of Illinois farmland and buildings.

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ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

IN THIS ISSUE

Solar energy can be harnessed for low-temperature grain drying (page 5).

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE Volume 19, Number 2

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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(Cover picture by Larry Baker)

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DAHL HEADS OFFICE OF COMMUNICATIONS

DELBERT T. DAHL was named head of the Office of Agricultural Communications on December 21, 1976, after serving on the staff in various capacities for several years. This office services the College of Agriculture, the Illinois Agricultural Experiment Station, and the state and county staffs of the Cooperative Extension Service. Research information and news about agriculture and home economics leave the Office of Agricultural Communications and reach agricultural and consumer audiences via news articles and feature stories; radio, television, and TeleNet programs; and photographs and other visual aids. Staff members also teach courses on agricultural communications for college students and conduct workshops on the use of mass media for county Extension personnel.

A native of Illinois, Professor Dahl received his B.S. degree from the University of Illinois in 1962. After three years as an assistant farm adviser in Stephenson County, he returned to the University on temporary assignment as 4-H Extension specialist. Subsequently he completed his work for his M.S. degree and in 1967 was named communications specialist in the Office of Agricultural Communications. From 1970 to 1973 he was media services coordinator, leaving in 1973 for a brief term as communications specialist with the U.S. Department of Agriculture in Washington. Returning to Urbana-Champaign, he served as administrative editor for the College of Agriculture until his present assignment.

Professor Dahl succeeds J. F. Evans, who has returned to full-time teaching after nearly two years as acting head. The headship became vacant in February, 1975, with the retirement of Hadley Read. Professor Read had been with the College since 1947, and it was under his direction that the Office of Communications developed the present scope and variety of its services. — *G. W. Salisbury*

Perspectives On Nutrition

Sensible food selection and a moderate caloric intake can improve overall health and increase life expectancy

DAVID H. BAKER

NEVER before in the history of man has there been such a wide array of foodstuffs to choose from as we now enjoy. It is little wonder that people have recently become much more interested in the food they eat. Yet, because of misleading advertising, misinformation, and, yes, human gullibility, more far-out and often dangerous dietary regimes are followed today than ever before.

Certainly, if we believed all the current "scare literature" about various foods, we would likely quit eating altogether! Obviously this is not the solution. Thus, I would like to briefly examine several of the food fads currently making the rounds.

Saturated fat

Research evidence indicates that we should probably reduce our intake of saturated (hard) fats, especially if our blood cholesterol level is above the norm. This is far from clear, however, as is indicated by the recent finding that some oleomargarines are more conducive to atherosclerosis than butter. This is because the polyunsaturated vegetable oils used to make margarines must be hydrogenated or hardened, and this process gives rise to trans fatty acids which seem to encourage hardening of the arteries.

Protein

We consume two to three times more protein in the United States than is necessary to meet our minimal requirements. The American taste for meat, milk, eggs, cheese, and peanut butter is undoubtedly the primary explanation for this overconsumption.

While animal-source proteins (meat, eggs, and dairy products) are very nutritious, the health aspect of these foods is a point of contention among nutritional scientists. In recent years, some nutritionists have claimed that too much meat and too little fiber in the Western diet is the principal reason why cancer of the colon and rectum is so prevalent. It appears now that neither too much protein nor too little fiber *per se* is responsible. Instead, fat in the diet (saturated and unsaturated) seems the more likely culprit. Thus, the positive association between meat consumption and fat consumption, together with the fact that many meat products contain a considerable quantity of fat, led to erroneous conclusions.

Eggs contain the most nearly "perfect" protein and also great quantities of minerals and vitamins. Fat and cholesterol, however, are also abundant, especially in the yolk. Although a cause-and-effect relationship between atherosclerosis and dietary cholesterol is far from established, persons with an above-normal blood cholesterol level would be well advised to restrict their intake of eggs.

Milk is very nutritious and often ameliorates a variety of dietary errors. It is an excellent source of calcium, phosphorus, and high-quality protein. The calcium is particularly important because it balances out the excess phosphorus contained in many soft drinks and prepared foods.

To be sure, some individuals, especially blacks, are intolerant to the carbohydrate (lactose) in milk, but for those who have no problem metabolizing lactose, milk provides a relatively simple and safe way of balancing one's diet and obtaining available calcium. Still, some have contended that, because of the xanthine oxidase in homogenized milk, consumption should be curtailed or even eliminated. The xanthine oxidase-coronary heart disease association is just that — an association like any number of associations that could be cited about almost every food.

Carbohydrate

Civilized man consumes far too much soluble carbohydrate (sugars, starches, etc.), especially when it is realized that carbohydrate calories are converted to body fat more efficiently than either fat or protein calories. Thus, overconsumption of carbohydrate results in obesity, which, needless to say, causes a variety of physical and psychological problems. It makes little difference whether the carbohydrate comes from refined sugar (sucrose) or from starches (bread, potatoes, etc.); both are assimilated similarly once digested.

Sucrose has been alleged to contain "empty calories," and this is exactly correct! Its principal purpose is to improve palatability and provide energy rather than to furnish other nutrient properties. Obviously, diabetics and persons with a history of heart disease or carbohydrate-related metabolic disorders should follow a physician's advice about using table sugar. Otherwise, sensible use of sucrose will likely cause no health problems.

On the other hand, it would be quite easy to indict most of the sugar substitutes now in use. Sorbitol, for example, which is found in "sugar-free" chewing gum and certain artificial sweeteners, can be metabolized by the body to fructose, the component of sucrose alleged to be noxious. Also, questions still remain about the possible carcinogenic effects of sac-

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charin, another sugar substitute frequently combined with sorbitol in "sugar-free sweeteners."

Actually, anything containing sorbitol should not be labeled "sugar-free" because sorbitol is every bit as much a sugar as sucrose (table sugar), glucose (fruit or corn sugar), or lactose (milk sugar). Also, "sugar-free" chewing gums, most of which contain sorbitol, are little better for preventing cavities than regular chewing gums. The bacteria of the mouth can ferment sorbitol almost as readily as sucrose — and it is the bacterial action that sets off the tooth-decaying process, not the sugar *per se*.

Most nutritionists agree that recent dietary trends have resulted in a drastically reduced intake of insoluble carbohydrate, better known as fiber. It has been estimated that in the past 100 years fiber intake from fruits and vegetables has declined 20 percent; and from cereals and grains, as much as 50 percent. Most of this decrease can be attributed to the increased use of refined flour and the replacement of whole meal cereal with processed ready-to-eat breakfast cereals.

It has been known for generations that fiber, though furnishing few nutrients, helps to maintain regularity. Moreover, as fiber consumption goes down, consumption of soluble carbohydrate and fat (and calories) goes up. This is precisely why obesity has become so widespread in the Western World. Thus, although inadequate fiber intake may not in itself be directly related to the increased incidence of bowel cancer, coronary heart disease, and atherosclerosis, increased consumption of fiber-rich foods like bran and raw fruits and vegetables is recommended.

Vitamins and minerals

With a normal diet including all the basic food groups, supplemental minerals and vitamins are unnecessary. It is very questionable if large doses of vitamin C will prevent or cure the common cold, and excess vitamin E won't prevent aging or enhance virility. During infancy and pregnancy and in certain disease states, vitamin-mineral therapy based on reliable advice may be necessary. Folic acid (a B-vitamin) and iron are generally prescribed in pregnancy, and infants should receive a multiple-vitamin preparation during their first six months.

Vegetarians would be well advised to seek nutritional counseling, since some common vegetables contain bound, unavailable vitamins and minerals which the body cannot fully utilize. And strict vegetarianism without necessary supplementation (especially vitamin B-12), will lead to what is known in nutrition circles as the four D's — dermatitis, diarrhea, debilitation, and ultimately death — if the situation is not corrected.

Special foods

If you like "health foods" and are willing to pay the extra money for them — fine. But don't expect miracles. The following conclusions would appear warranted:

Organic foods (foods grown without synthetic fertilizers, herbicides, insecticides, fungicides, or hormones, and processed without thickeners, stabilizers, bleaches, emulsifiers, buffers, dyes, preservatives, or additives) are, as a rule, neither more nutritious nor safer than regular foods. Crops grown organically (it is always questionable if they really are) contain the same nutrient quantity and quality as those grown otherwise.

Enzymes. It is nonsense to think that consumption of enzymes will aid health. Enzymes are completely broken down before the body absorbs their products of digestion from the small intestine. The virtue of raw fruits and vegetables is their vitamin, mineral, and fiber content and not their enzyme content.

Lecithin. There is no evidence that lecithin (a phospholipid) will guard against heart attacks or will lower blood cholesterol. Like enzymes, lecithin is made naturally in the body and also occurs abundantly in such crops as soybeans. Claims concerning lecithin are clearly misleading.

Fertile eggs are not more nutritious than unfertile eggs.

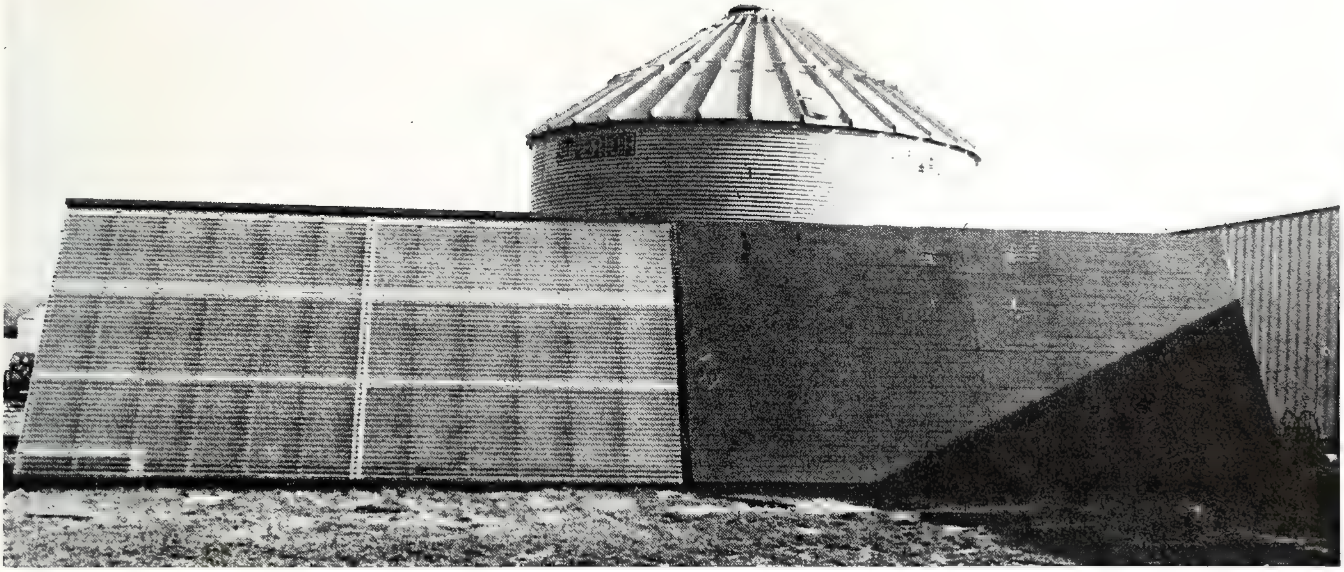
Natural vitamins (those in food and those derived from "natural" products such as rose hips) are more likely to contain less than 100 percent of listed potency than synthetic vitamins. Several vitamins, notably folacin, are partially bound or unavailable in "natural" products. At the absorption site in the small intestine and at the cellular level, the body does not distinguish between natural and synthetic vitamins since they are identical chemically.

Toxins in foods. It is true that potatoes contain solanine (notorious for its presence in the deadly nightshade plant); lima beans contain cyanogenic glucosides which produce hydrogen cyanide; spinach and rhubarb contain oxalic acid; soy and kidney beans contain at least seven inhibitors or toxins and several exotic sugars including fructose; nutmeg contains myristicin (a hallucinogen); lettuce contains estrogenic compounds; and tuna fish contains traces of mercury and cadmium. However, sensible consumption of these foods generally causes no health problems. At the same time, we should continue to seek means of removing these substances from our food supply. Also, efforts should continue toward preventing environmental contamination with heavy metals as well as with chlorinated hydrocarbons and other toxicants.

Moderation important

Nutrition is a science based on sound biochemical facts and on logic that transcends both time and fads. Dietary deficiencies and other nutritional problems seldom arise from food itself, but from people's food choices — often choices which lead to premature destruction of body organs and cells.

It would be wise to practice moderation in dietary matters and to seek the counsel of a qualified nutritionist before embarking upon any new diet. And two other pieces of advice are important for most adults in the Western World: Reduce caloric intake, and get more exercise.



Covered plate and bare plate solar collectors used in grain-drying experiments at Urbana. **(Fig. 1)**

Drying Grain With Solar Energy

GENE C. SHOVE

WITH FUEL costing more and more and its use actually being curtailed in some areas, Illinois corn growers are concerned about getting, and paying for, the large amount of energy needed to dry their corn. A partial solution to the problem may lie in utilizing solar energy.

The feasibility of solar grain drying has been indicated by studies begun in the Department of Agricultural Engineering before the 1974 corn harvest. Solar energy appears to be especially well suited to low-temperature drying, which utilizes small increases in drying air temperature over extended periods. Although a constant source of energy for drying is preferable, intermittent application of heat is acceptable in low-temperature drying. The long-time drying can continue even when rainy weather or heavily overcast days keep the sun's energy from penetrating to the earth's surface.

Solar energy can be stored, for example by heating a tank of water, for use at night and on cloudy days. However, storage systems are bulky, require additional equipment for reclaiming the stored energy, and consequently are costly to install and maintain.

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Materials and installation

There are two types of solar collectors: "Covered plate" collectors consist of a black energy-absorbing surface covered with a clear material such as corrugated fiberglass. "Bare plate" collectors are made of a black energy-absorbing material without a cover.

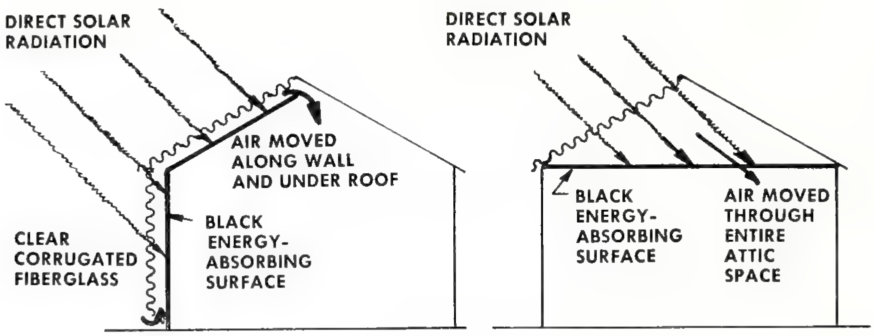
Collectors are relatively simple to install on surfaces of grain drying bins and other farm buildings or as free-standing units (Fig. 1). No major modifications in building design or construction are necessary to incorporate collectors into a building. The collectors should be installed on south-facing walls and roofs, because of the favorable orientation to the sun.

Even an entire attic can be incorporated into a heat-collecting system for drying grain, with the floor of the attic forming the black absorber plate (Fig. 2). The large volumes of air used in drying grain move over the absorber plate at high velocities. As the air picks up heat from the absorber plate, the plate's temperature is decreased. The lower this temperature, the higher the collector's efficiency.

The heat collected can be used for multiple purposes. For example, a collector incorporated into the roof of a swine building can heat air for drying grain before wintertime heat is required for hogs housed in the building. Similarly, collectors in machinery storage buildings can provide heat for shops as well as for grain drying.

Enough heat is collected

Data were collected in 1976 for four covered plate grain-drying collectors installed on surfaces of varying sizes and configurations. Maxi-



Two methods of installing a solar collector in a farm building. **(Fig. 2)**

Table 1. — Air Temperature Rises From Covered Plate Solar Collectors, 1976

Collector configuration	Area, sq. ft.	Fan hp.	Temp. rise, °F. Max.	Temp. rise, °F. 24-hr. aver.
Vertical wall and 20° roof	1,400	20	17	4
Vertical wall and complete attic	4,500	10	30	6
Horizontal roof	6,000	12½	30	7
60° wall	288	5	15	4

mum temperature rises of 15° to 30° F. were achieved at solar noon, when the sun's rays are most intense and strike south-facing collectors most directly (Table 1).

Maximum temperature rise, however, is only one criterion in evaluating solar collectors. It is the total energy collected that must evaporate moisture from the wet grain being dried. Therefore, the energy (or temperature rise) obtained during the daylight hours must be averaged over the entire 24-hour day. Approximate 24-hour average temperature rises as given in Table 1 indicate that the collectors were adequate for low-temperature drying, which in most years requires a temperature rise of 3° to 5° F.

Actually, at least two of the collectors would probably have over-dried the corn if the bins had not been equipped with grain-stirring machines. One reason was the favorable drying conditions and large amount of sunshine during the 1976 corn-drying season. Another was the fact that the average air temperatures would have been increased an additional 2° to 3° F. as the air passed through the fans.

The study included a comparison of the efficiency of a bare plate and a covered plate collector (Fig. 1). With an air flow of 14.6 cfm per square foot of collector surface, the bare plate unit collected only 50 percent of the available solar energy as compared to 70 percent for the covered plate.

Economic studies incomplete

Feasibility studies to prove a concept are only part of the development and application of new technology to practical production systems; economic studies are also necessary. However, as often happens when external forces require the rapid implementation of new technology, economic studies of solar grain drying have lagged behind the feasibility studies.

Multiple use of solar collectors complicates the economic justification analysis. There is no question that multiple use provides a broader base for economic justification, but assigning dollar and cent values is more difficult than for a single use.

Even though cost-benefit ratios have not been defined, the realization that fossil fuels may soon be in critically short supply provides an incentive to install solar grain-drying systems, particularly when new farm buildings are being constructed. Solar energy is a renewable resource that can be expected to provide a greater and greater portion of our future energy requirements.

Wood as Fuel . . .

POO CHOW

Surprisingly to most of us, the largest single use of wood in the world is not for paper or lumber, but for the oldest use — fuel. In the less industrialized countries, fuel wood accounts for 70 to 95 percent of the annual harvest of roundwoods.

The United States consumes only about 8 million tons of fuel wood, or 4 percent of its roundwood production, because fuel wood generally has the lowest value and least demand of any wood product. However, 7 to 8 million tons of wood and bark residue fuels are used every year to generate steam and power at or near U.S. forest product industries.

In light of the present and predicted future energy shortage, it seems appropriate to explore the possibilities of using more wood as fuel in this country.

Caloric value of wood fuel

Dry wood ignites readily and leaves less than 1 percent ash, which has some fertilizer value. Sulfur content of the wood is negligible. Table 1 shows the average fuel analysis of dry hardwood and bark.

The heat value averages about 8,500 Btu per pound of dense hardwood species such as oaks, hard maple, ash, beech, hickory, and birch on an oven-dry basis. By comparison, coal yields about 13,000 Btu per pound and fuel oil, 19,000 Btu. Theoretically, the amount of heat obtained from a ton of oven-dry hardwood and bark equals that from 3 barrels of fuel oil or 0.65 ton of coal.

The greatest drawback to wood as a fuel is its high moisture content when harvested. Wood with a moisture content of 45 percent has a heat value of only 6,000 Btu per pound.

Industrial fuel

The largest industrial use of wood residues and spent pulping liquor is to burn them to produce steam, which is then used for drying veneer,

. . . Forests Can Be Utilized More Fully as an Energy Source

lumber, and wood particles or fibers. A steam plant's capacity may range from 10,000 pounds of steam per hour to more than 500,000 pounds at large paper mills.

Today technology is available to build wood-waste fueled plants for generating electric power while meeting governmental pollution control standards.

Sometimes wood can be had for the asking.

Fuel for fireplaces

At present there are more than 20 million fireplaces in the United States. Newly designed fireplaces or wood stoves that supplement a heating system could increase the domestic use of fuel wood. (Information about using wood in fireplaces efficiently is given in Leaflet No. 1 of the Department of Forestry, University of Illinois. Single copies may be obtained from the Department of Forestry, 211 Mumford Hall, Urbana, Illinois 61801.)

To overcome the bulkiness of wood, bark, and wood residues, such as sawdust and shavings, these materials can be formed into densified briquettes or compressed "logs." These pieces are dry and will burn for a long time, with a 5- or 6-pound log emitting at least 45,500 Btu of heat in a fireplace or wood stove.

Charcoal and by-products

Charcoal, another form of wood fuel, is obtained by distilling roundwood or wood and bark residues under controlled conditions in the absence of air. Compared with the wood used, charcoal has about 50 percent of the volume, 20 to 30 percent of the dry weight, and twice as much heating value. The heat generated is similar to that of high-quality coal.

Table 1. — Average Fuel Analysis of Dry Hardwood and Bark by Weight

Constituents	Wood, pct.	Bark, pct.
Hydrogen	6.0	5.5
Carbon	52.0	54.0
Nitrogen	0.1	0.2
Oxygen	41.0	38.0
Sulfur	0.1	0
Ash	0.8	2.3

Charcoal gives out little smoke or odor, so is widely used for broiling and roasting foods in restaurants, trains, and homes in many countries. It is also a good fuel for campers and picnickers, since it does not blacken cooking utensils.

The charcoal industry provides an outlet for low-grade hardwoods that have no other market. More than 500,000 tons of charcoal are produced in the United States every year.

The distillate remaining after charcoal production can be refined to produce gaseous and liquid fuels in addition to the charcoal. It has been estimated that one cord of dry hardwood (2,750 pounds) yields these fuels:

Charcoal	1,000 pounds
Noncondensable gases (325 Btu per cu. ft.)	10,000 cu. ft.
Methanol	20 gallons
Methane	3 gallons
Wood oil and tar	22 gallons
Ethyl acetate	15 gallons
Ethyl formate	1 gallon
Pitch	66 pounds
Creosote oil	3 gallons

Energy plantations

In remote areas of many developing countries, forests of fast-growing hardwood species are specifically managed as renewable sources of fuel for homes and industry. The drawback to such energy plantations in the United States is the enormous land requirements for any significant addition to our energy supplies. Fueling even 1 percent of this country's electrical generating capacity would require 2 to 5 million acres of fuelwood forest. However, our existing forests can be managed more efficiently to supplement our fuel supply.

New industry in Illinois

According to the U.S. Forest Service, the desirable cut of Illinois forests is nearly four times the present timber harvest. A total of 112 million cubic feet or 2 million tons of extra wood could be made available annually by harvesting mature trees in low-quality hardwood stands and by thinnings and improvement cuttings in younger stands. This would offer a good opportunity to develop new wood-based industries in Illinois.

For example, the manufacture of briquettes or of charcoal and gaseous fuel by distillation would not only create new energy sources but also provide a market for small and low-grade hardwood timber and improve timber stand quality and forest management. Further study is needed to expand the state's wood distillation and charcoal industries and to make them more efficient.

Poo Chow is associate professor of wood science, Department of Forestry.

Reclaiming Surface-Mined Soil: *Completed and Proposed Studies*

J. B. FEHRENBACHER, I. J. JANSEN, and S. R. ALDRICH

ILLINOIS has the largest bituminous coal reserve of any state in the nation. About 13 percent of this coal is considered strippable, and part of the strippable coal underlies some of our most productive soils. Over the past several years 5,000 to 6,000 acres a year have been surface-mined in Illinois, with the total reaching about 186,000 acres in mid 1975. This process may be accelerated with increased use of coal.

To lessen the impact of surface mining on our food-producing capacity and on the environment, the Illinois legislature passed the Surface-Mined Land Conservation and Reclamation Act in 1971. A 1975 amendment requires that certain surface-mined land be reclaimed for row crop production.

The choice of land to be reclaimed for row crops is made by the director of the Department of Mines and Minerals on the basis of a soil survey before mining begins. This land must be graded to certain slope specifications with adequate erosion control measures and must meet certain textural requirements in the upper 4-foot rooting zone. The original 8 to 18 inches of darkened surface soil must be saved and returned to the land after the final grading. Precise specifications for reclamation are given in Rule 1104 of the Act.

Rule 1104 was developed from knowledge of the properties and producing capacity of Illinois soils before mining, the water and nutrient requirements and rooting habits of grain crops, and average climatic conditions. However, not enough is known about the effects on row-crop production of various characteristics in the reclaimed land — for example, depth and texture of the rooting zone, the presence of rock fragments, the thickness of the replaced darkened surface soil, erosion, and drainage. In research planned for 1977 and beyond, we intend to study the properties of reclaimed land.

J. B. Fehrenbacher is professor of pedology; I. J. Jansen, assistant professor of pedology; S. R. Aldrich, professor of soil fertility extension and assistant director of the Agricultural Experiment Station.

Research before 1977

The Illinois Agricultural Experiment Station has conducted research on surface-mined land for more than 30 years. The earliest experiments were conducted when there were no legal requirements for leveling the land, for providing a suitable rooting medium, or for replacing surface soil.

In 1945-1947 the Illinois Station cooperated with the Central States Forest Experiment Station in experimental tree plantings on strip-mined lands. Eight conifers and ten hardwood species showed possibilities.

Intensive studies of grass and legume growth on cast overburden were begun in 1947 with financial aid from the Illinois Coal Strippers Association. A number of species provided good yields of high-quality forage.

In later studies, wheat, rye, and barley produced satisfactory yields on freshly graded and leveled spoils. Corn and soybean yields were low unless they were preceded by several years of grass-legume crops. Even then, the physical condition of the soils caused problems.

In 1963-1965, Leonardite, an amorphous coal-like organic material, failed to improve yields of corn, soybeans, wheat, or alfalfa on freshly leveled spoils.

Several recent studies have concerned sewage sludge applications on strip-mined lands. One, in Fulton County, was made in cooperation with the Metropolitan Sanitary District of Chicago and the U.S. Department of Health, Education, and Welfare. According to the results, sewage may be a good source of organic matter, nitrogen, and phosphorus on disturbed soils, especially if the original darkened surface soil is lacking. Another study showed that sludge plus limestone is effective in establishing vegetation on very acid mine wastes.

Continuing studies by Veterinary Medicine concern the survival of pathogens in sewage sludge and the possible effects on animal health when sludge is applied to agricultural land.

According to recent economic studies, the impact of strip mining on assessed valuation and taxes depends on land use following reclamation. Other studies have concerned the economics of land reclamation combined with waste utilization.

One study revealed that food production on excellent farmland cannot compete financially with mining an underlying thick coal seam unless the mined land can never be fully reclaimed for crop production and the time span is very long.

Plans for 1977 and beyond

In comprehensive studies beginning this year, Experiment Station personnel hope to develop information that will improve reclamation procedures without adding unduly to energy costs. Several coal companies and federal agencies are providing financial support. Specific areas of research that we plan to undertake are briefly outlined in the following paragraphs.

Changes in amount and condition of cropland. With current surface-

mining procedures, 15 to 30 percent of the land is lost. This is due to final cuts, water impoundment, and steep slopes associated with haulage roads. We plan to compare the amount of potential cropland before and after mining, and will evaluate possible ways to reclaim more of the cropland.

We will also determine the influence of pre-mine landscape, mining procedures, and age on conditions following reclamation. Active mines will be photographed periodically from the air to document landscape features, mining procedures, position of box cuts and haulage roads at specific times, and topography of the spoils before and after grading. Soil maps, topographic maps, field investigations, and laboratory analyses, together with the aerial photographs, will be used to characterize pre-mine and post-mine soils and landscapes.

Factors that affect crop rooting and stands. Root system development in spoils and in nearby unmined land will be compared. Features in spoils that are favorable or unfavorable to root system development will be determined and evaluated. Crop stand problems on farmed spoil lands will also be investigated to determine the severity and cause.

Because of the importance of moisture in root development, it is planned to emphasize the hydrology of mined land. By measuring the amount of surface crusting that results from raindrop action, infiltration will be determined at several spoil sites with differing amounts of soil cover. The work will be coordinated with studies of seedbed preparation, seedling emergence, and erosion.

We plan to monitor permanent and perched water table levels, soil water depletion by plants, and the directions and rates of soil water flow in spoil materials.

Spoils of varied character will be studied in the laboratory and in the greenhouse to calculate the available water-holding capacity. Data from water table levels and available water in various soil and rock combinations will help determine textural requirements for good crop growth on reclaimed land.

Erosion problems on reclaimed land that is being farmed will be studied in order to determine what combination of management practices and slope will control erosion. Another erosion-control project will involve the study of land forming and final grading procedures.

Where differential settling is great enough to create management problems, we will try to determine mining and reclamation procedures for minimizing the problems. Periodic aerial photographs will be used to indicate areas where erosion is severe, where stands are poor, and where settling over time has caused changes in the degree of surface drainage problems.

Segregation and replacement of darkened surface soil and root medium. In southern and western Illinois, surface soil will be replaced on wheel, dragline, and shovel-haul spoils. Varying thicknesses of surface soil up to 18 inches will be tried.

Additional plots will be established on graded cast overburden with no surface soil. Special management practices, including the use of legumes and grasses as the main crops, will be followed and the results compared to those on plots with replaced surface soil.

Still other plots will be established on areas that were surface-mined at various times before 1975. The effectiveness of natural soil development, over time, on these plots will be compared to surface soil replacement.

All plots except the special management plots will be planted to corn and soybeans in rotation. Soil tests will be used to determine fertilizer rates. Yield data will be plotted according to thickness of the replaced surface soil and root medium.

Rate of soil development. Studies to assess the degree to which soil development has modified spoil lands over time will be made on spoils that vary in age but were originally similar in composition. Such things as rate of organic matter accumulation, development of structure, and breakdown of coarse fragments will be included. Factors such as the kind of vegetation known to affect the rate of soil development will be evaluated separately.

How moisture content at various stages of handling spoils affects moisture regime in reclaimed land. Soil moisture near the surface varies widely depending on rainfall, evaporation, and use of water by plants. Moisture at somewhat greater depths varies seasonally. At depths well below plant rooting and soil development, moisture content may be relatively constant over time. Hence seasonal soil moisture patterns may be more significant than the near-surface wetness determined by the daily balance between precipitation and evapotranspiration.

Periodic aerial photography will document the time of overburden movement, final grading, and surface soil replacement. Soil moisture status at specific sites during grading or mining will be determined near the time of aerial photographic coverage. This will permit extrapolation of results to a larger area. Soil physical properties at numerous sites will be measured periodically and differences will be related to moisture content at the time of mining and grading.

Use of runoff for irrigation. The water which fills the excavations left by mining operations may often be used for irrigating crops. Irrigation plots will be established on strip-mined land, with subplots for the study of fertilization and other management variables. Both surface and overhead applications will be tried. Relationships between plant growth, soil conditions, weather, and water use efficiency will be determined. A further objective is to study the recharge rates of the ponds and their adequacy as a source of irrigation water.

The research outlined above is planned to last at least five years. It will be primarily under the direction of I. J. Jansen and C. W. Boast of the Agronomy Department. Sites for the studies have not yet been chosen, but it is felt that plots should be established in both western and southern Illinois.

Utilization of Livestock Wastes: *Alternative Treatments and Products*

H. C. KIM and D. L. DAY

LIVESTOCK on American farms produce about 2 billion tons of manure each year. To protect the environment from this potential pollutant and to recover usable materials from it are the major objectives of livestock waste management.

A large variety of products can be obtained from livestock wastes. Major possibilities are illustrated in Figure 1 with a block diagram. Treatments are classified into three categories — biological, chemical, and physical. Component blocks indicate the types of products that can be obtained with each treatment.

Each product probably determines, or is determined by, the type of facility, the method of collecting and handling wastes, the kind of animal, and the desired method of utilization. For example, ruminants can utilize non-protein nitrogen, but nonruminants must have nitrogen in the form of protein. Refeeding of ODML (oxidation ditch mixed liquor) is therefore more economic in swine production than in beef cattle production. Dehydration is best used for poultry manure as it naturally has a low water content.

Biological treatments

The historic practice of *spreading manure* on cropland as a fertilizer and soil builder is still the most widely used alternative. In general, the essential inorganic fertilizer components are partially utilized by crops, and some of the organic complex penetrates into the soil matrix and combines with soil particulates, thus improving the soil properties.

Another biological treatment is *hydroponic culture,* or growing plants on the surface of waste water. The roots upgrade the water by filtering some of the chemical pollutants and converting inorganic nitrogen into organic nitrogen.

Composting, an aerobic process, offers an opportunity to recover part of the nutrient and organic fractions in solid waste. Adding such material as ground corn cobs, straw, and wood chips reduces the moisture content, facilitates aeration, and reduces composting time. It has been reported from a number of studies that active composting takes place at a pH between 8 and 9, and that the volume of the compost windrows is reduced by 50 percent after 15 to 18 weeks. With frequent stirring and mechanical aeration, composting can be completed in 3 weeks.

Aerobic digestion of swine waste in oxidation ditches has been studied at the University of Illinois for several years. A single-cell protein (SCP) is produced in the oxidation ditch mixed liquor (ODML). When ODML is fed to swine, the protein content of the main feed can be reduced by about 15 percent. Odor in the oxidation ditch can be adequately controlled by proper circulation and aeration.

Anaerobic digestion of animal wastes to reduce pollution potential and reclaim an energy source has received attention from many researchers. This is one of the attractive approaches to the energy problem.

The efficiency of the treatment depends upon the type of substrate and the operating conditions, such as temperature, pH, and the length of time that the substrate is in the digester. In general, as much as 60 percent of the volatile solid is broken down, and 1 pound of volatile solid destroyed produces about 10 standard cubic feet of bio-gas (mainly methane), containing about 6,000 Btu. Digested slurry can be used as a fertilizer.

Wastelage, developed at Auburn University, is made by *ensiling* mixed manure and hay. The process increases the palatability of manure, while controlling pathogens and preserving the nutrient level. Wastelage is ready to be fed after 2 to 3 weeks in the silo. It utilizes up to 50 percent of the manure produced by beef animals as a feed supplement for the same animals.

Physical treatments

Dehydration has been widely used to make the wastes easier to handle. The dried product can be utilized as a soil conditioner or as a feed supplement. Dried poultry feces have been successfully substituted for 10 to 12 percent of the diet (on a dry matter basis) of cattle and hens without decreasing performance.

Scientists at the U.S. Department of Agriculture have studied *fractionation* of feedlot waste. The waste is separated into discrete fractions — residue, solids suitable for feed supplement, and solubles. It was demonstrated that about 70 percent of the total nitrogen can be recovered from the waste as a potential feed fraction, and the residue fraction can be pressed into fiberboard-like products.

Chemical treatments

Research at the Bureau of Mines has included pilot experiments for converting bovine waste to oil and gas energy. Two methods have been tried — *hydrogenation* and *pyrolysis.* Both methods are largely based on

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the historical technologies of coal liquefaction and gasification, since manure is considered a source of hydrogen and carbon atoms just as coal is.

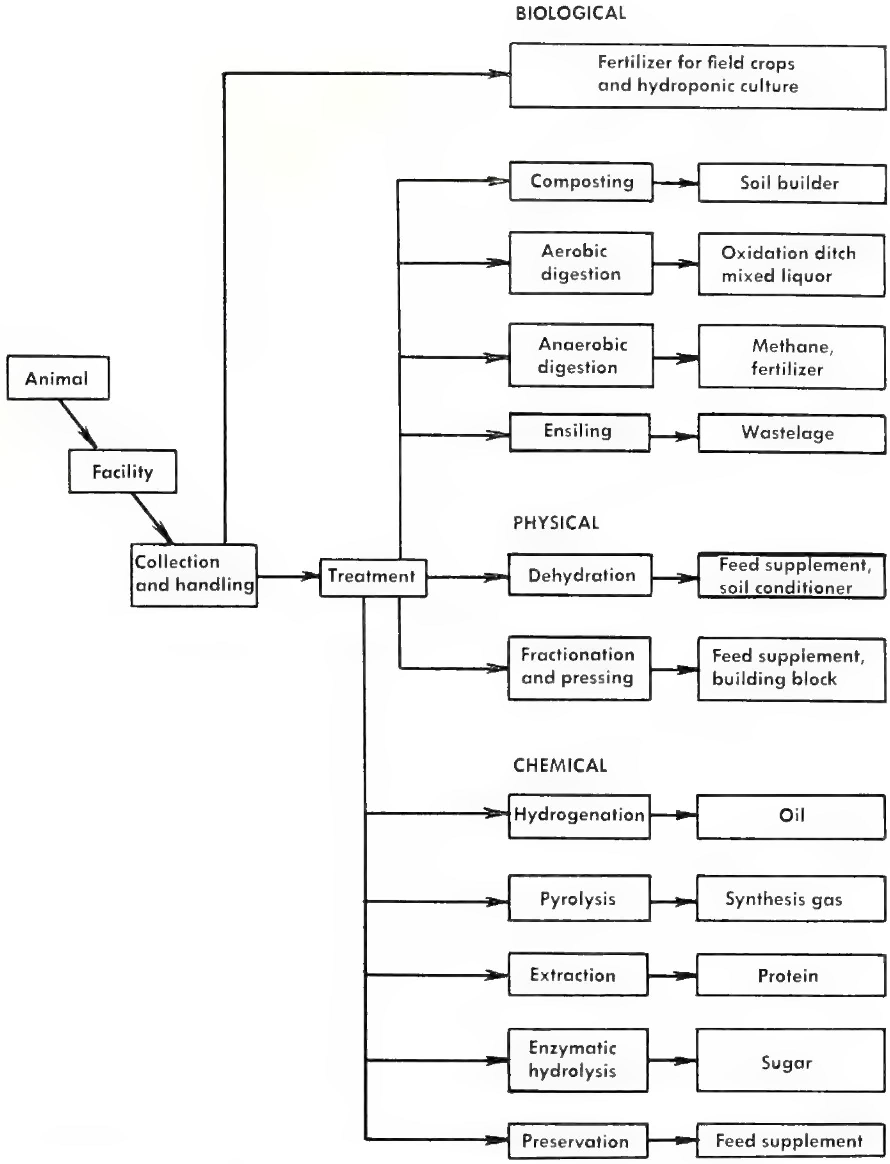
In the hydrogenation process, the manure is heated under pressure at 380° C., in the presence of carbon monoxide and steam, for about 20 minutes. The result is a heavy, largely paraffinic oil with a heating value of 14,000 to 16,000 Btu per pound and a sulfur content of less than 0.4 percent.

With the pyrolysis method, the bovine waste is heated for about 6 hours at 900° C. in a closed chamber. At this temperature, the material is converted to gases, such as carbon monoxide, hydrogen, and methane. The mixture of gases has a heating value of about 500 Btu per cubic foot. In addition, an oil-like material (15,000 Btu per pound) and a solid fraction (5,000-13,000 Btu per pound) are obtained, which can be used to provide some of the heat needed for this treatment. Results of an economic analysis strongly favor pyrolysis over hydrogenation.

At Colorado State University, *extraction* has been studied as a means of recovering a protein-rich feed supplement from livestock wastes. Fresh waste extracted with 1 normal of sodium hydroxide contained as much as 340 milligrams of protein per gram of manure on a dry basis.

Other research at Colorado has concerned *enzymatic hydrolysis*. With the use of strong oxidants, some cellulosic fractions of the waste were converted into sugar. Up to 230 milligrams of glucose equivalents of reducing sugar was obtained per gram of manure.

Chemical *preservation*, studied at the University of Illinois, results in a product that is similar to wastelage except that it does not need to be ensiled. A low level of formalin is added to the fresh manure. This controls pathogens and odors, increases palatability, and preserves the nutritive value. Other feeds are then added to formulate a balanced ration. Like the wastelage process, chemical preservation permits about half of the manure to be returned to beef animals as a feed supplement.



Alternative methods of treating and utilizing livestock wastes. (Fig. 1)

Cost analyses

Four common treatments have been analyzed in terms of energy and monetary budgets, assuming hypothetical facilities that market 4,000 hogs a year. The use of manure for fertilizer was found to be least expensive. This was followed by anaerobic digestion for methane gas, oxidation ditch for the production of single cell protein (SCP), and dehydration for feed supplement.

Varied possibilities

The alternatives described so far have been extensively studied. Some are ready for application, but most are still in the exploratory stages. Extensions of some of the alternatives may also be considered. For example, an extension of the pyrolysis method gives a chance of obtaining methanol and ammonia.

With all these various possibilities, there is a tremendous potential for recovering fertilizer, feed, and fuel from feedlot wastes while achieving pollution control.

Survival of Free-Living Stages Of Sheep Nematodes on Pasture

NORMON D. LEVINE and KENNETH S. TODD, JR.

NEMATODES or roundworms in the stomach and intestines of sheep and cattle are the most important parasites of these animals in Illinois. They are responsible for heavy losses among young animals, especially lambs.

We have been studying nematodes for quite a few years to find out how to control them without drugs. We have been using sheep because they are cheaper and easier to handle than cattle, but their parasites are about the same, and the results should also be the same.

Nematodes do not multiply in their host. The females in the stomach or intestine lay microscopic eggs which pass out with the droppings. Each female lays hundreds to thousands of eggs a day. After a short period of development, the eggs hatch and microscopic larvae (tiny, immature worms) emerge, which develop on pasture to a stage which is able to infect an animal. These larvae then leave the droppings and climb up onto the vegetation, where they are too small to be seen. They infect grazing sheep or cattle.

Possible control methods

The nematodes can be attacked in a host animal by treating it with a drug, or they can be attacked when they are on pasture. Drugs give only partial control, and the worms may become resistant to them. In addition, the drugs may be harmful to the host. Elimination of the worms while they are on pasture is a hopeful approach, but little has been done along these lines. We have been studying the problem along with Dr. Ferron L. Andersen, Paul A. Boatman, and others.

One line of attack would be to spray the pasture with a chemical that would kill the larvae while not harming the vegetation or the grazing animals. However, no such chemical is known.

Another approach, which has been recommended for years without saying much about how it should be done, is to rotate pastures. We found that lambs could be prevented from picking up worms if they were moved to fresh pasture every 2 days and never put back on any pasture that they had grazed. But this is extremely wasteful; it is not a satisfactory way of utilizing pasture. We could discover no method of pasture rotation that would prevent lambs from becoming heavily parasitized.

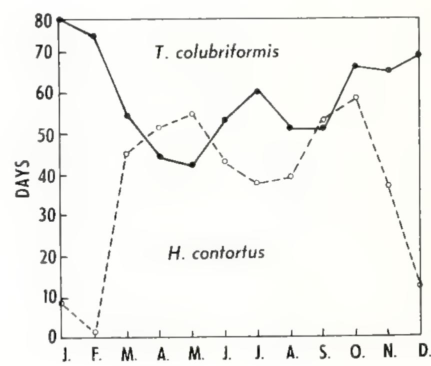
Larvae's survival studied

It takes the larvae 2½ to many more days to reach the infective stage, depending on the conditions. Then they can survive for a long time, again depending on the conditions.

We decided to find out what effects each condition had. We measured rain- and snowfall, dew duration, soil moisture, relative humidity, potential evaporation, solar radiation, and total wind movement. Also, we measured temperature in a standard weather shelter about 5 feet above the ground, at the ground surface under grass, on bare ground, at different depths in the soil, and in sheep fecal pellets.

We related these various conditions to the survival on pasture of the common intestinal nematode of sheep and cattle (*Trichostrongylus colubriformis*) and the common stomach nematode of sheep and cattle (*Haemonchus contortus*). For several years, we set up a new experiment every week from April through October and every two weeks from November through March. We set out both laboratory-incubated sheep fecal pellets containing infective larvae and fresh pellets containing eggs. We ran 140 experiments on *T. colubriformis* and 296 experiments on *H. contortus*.

In addition, we carried out numerous studies in the laboratory and studied our larval recovery techniques.



Number of days that the infective larvae of *Haemonchus contortus* and *Trichostrongylus colubriformis* were recovered from vegetation after they had been placed on pasture. (Fig. 1)

Norman D. Levine and Kenneth S. Todd, Jr., are professors of veterinary parasitology.

Conclusions

From all this work there emerged a number of conclusions:

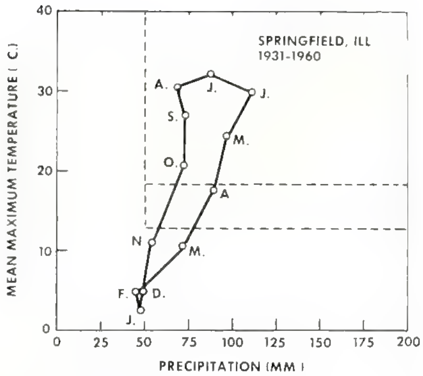
1. Although well over half of the eggs produce infective larvae in the laboratory, a very small percentage (0.03 percent for *H. contortus*) produce recoverable larvae on pasture. But these are enough to kill an animal after they develop into their adult stages.

2. Meteorologic conditions at the ground level, where the nematode larvae exist, are quite different from those 5 feet above the ground in a standard weather shelter. Furthermore, the amount and even the direction of the difference are not constant throughout the year. For instance, during a particular week in January, the average temperature in the weather shelter was 33.6° F., whereas it was 25.3° F. at the soil surface under 3 to 4 inches of grass. During another week, in July, it was 86.5° F. in the weather shelter and 96.6° F. at the soil surface under grass. In other words, the temperature was 8.3 degrees lower under grass than in the weather shelter during that week in January, but 10.1 degrees *higher* during that week in July.

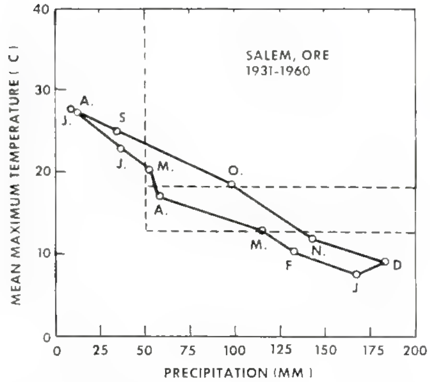
Since temperatures in the weather shelter are seldom the same as those where the larvae are, they cannot be used to calculate the effect of temperature on the larvae. But the weather shelter data are all that we have for most places.

3. Soil moisture is actually more important than rainfall or snowfall in determining larval survival. It results from rainfall, of course, but other factors such as soil texture, slope of land, and amount of shading operate as well.

4. There is a great difference between *Trichostrongylus colubriformis* and *Haemonchus contortus* in survival of the infective larvae on pasture. Indeed, the results obtained in different months were opposite (Fig. 1). *H. contortus* larvae survived the winter at Urbana poorly, whereas *T. colubriformis* larvae survived well. *H. contortus* larvae survived better than *T. colubriformis* larvae in the spring and worse in the summer, while both survived equally well in the fall. On the other hand, *H. contortus* larvae resist death due to repeated desiccation much better than *T. colubriformis* larvae, and this may explain the difference in geographic distribution of the two species rather than temperature per se.



Bioclimatograph of average monthly maximum temperature vs. monthly precipitation for 1931-1960 at Springfield, Ill. (a *Haemonchus* area). Dashed lines are the limits of optimum conditions for pasture transmission of *Haemonchus* (above) and *Trichostrongylus* (below). (Fig. 2)



Bioclimatograph of average monthly maximum temperatures vs. monthly precipitation for 1931-1960 at Salem, Oregon (a *Trichostrongylus* area). Dashed lines are the limits of optimum conditions for pasture transmission of *Haemonchus* (above) and *Trichostrongylus* (below). (Fig. 3)

5. One can get a rough idea of the species of nematode to expect from a bioclimatograph of the region. A climatograph is a closed curve produced by plotting the average temperature against the average precipitation (rain- or snowfall) for each month and joining the resultant points. A bioclimatograph is a climatograph on which lines have been placed to indicate the limits of some biological factor.

Figure 2 is a bioclimatograph for Springfield, Illinois, which plots the average monthly maximum temperature against average monthly precipitation for 1931-1960. On it are superimposed dashed lines which indicate the limits of optimum conditions for pasture transmission of *Haemonchus* and *Trichostrongylus*. The optimum precipitation for both nematodes is 2 inches (50 millimeters) or more a month, but the optimum temperatures differ. For *Haemonchus*, the optimum average monthly maximum temperature is above 65° F. (18.3° C.), whereas for *Trichostrongylus* it is 55°-65° F. (12.8°-18.3° C.). As might be expected, Springfield (and all of Illinois) is a *Haemonchus* area.

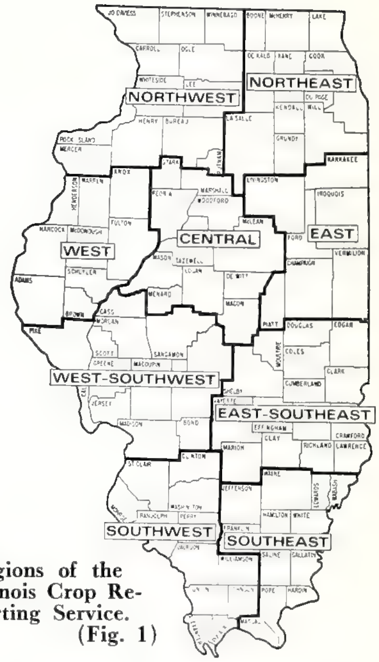
Figure 3 is a bioclimatograph for Salem, Oregon. The climate here is quite different from that in Illinois. In Illinois the average amount of precipitation is about the same throughout the year, but the temperature changes markedly. In Salem, the temperature does not change nearly so much, but the amount of rain does; it is a winter rain-summer dry area. A glance at its bioclimatograph indicates that *Trichostrongylus* should be much more important there than *Haemonchus*, and this is true.

Trying to predict what will happen to any particular larva or even group of larvae from our incomplete knowledge of all the factors is impossible. It is even beyond the power of a computer — we used the best available. We can't do it, but the larvae can. They put together all the microenvironmental factors that act on them. Sometimes one factor determines larval survival, and sometimes another, but the general picture remains fairly constant.

The next question is how to apply this information to the control of sheep and cattle parasites. We can't do it yet, but we're working on it, and we're not pessimistic.

Changes Over a Decade In Illinois Agriculture

MICHAEL BOWLING and J. C. VAN ES



Regions of the Illinois Crop Reporting Service. (Fig. 1)

As one would expect, preliminary Census data for 1974 confirm that farms are continuing to get larger, the number of farmers is still declining, and the value of farmland is rising dramatically.

To determine the extent of these changes in Illinois, we compared data for 1974 with Census data for 1964 and 1969. By studying the data for the regions of the Illinois Crop Reporting Service (Fig. 1), we could see how different regions of the state varied from one another and from the state average.

Number and size of farms

Total acres of farmland in Illinois declined steadily from 1964 to 1969 and even more drastically from 1969 to 1974 (Table 1). During the 10-year period, the number of farms decreased by 13 percent, with an average of 1,777 going out of business every year. The result was a net increase of 11 percent in average size of farm — from 225 acres in 1964 to 250 acres in 1974.

Every crop-reporting region of the state followed the same pattern, but the magnitude of change varied from one region to another. The decline in number of farms was above the state average in the northwest, northeast, and southeast; about the same as the state average in the west, southwest, and east-southeast; and several percentage points below the average in the west-southwest, east, and central regions.

While every region showed a decrease in amount of farmland, the most pronounced declines were in the northeast (8 percent) and southeast (7 percent). Average size of farm increased in all regions, but the northwest, northeast, and southwest had both the smallest average farm size in 1974 and the smallest average increase in farm size over the preceding 10 years.

Distribution of farms by size

In Table 2 we have an indication of the distribution of farms by size (excluded from Table 2 are farms with less than $2,500 income from farming). Between 1964 and 1974 a number of common trends can be observed in all the regions.

The decrease in number of farms during the decade was concentrated in the 50-499 acre category. The number of farms 500 acres and over increased from almost 10,000 to almost 15,000 or by 52 percent. Somewhat surprisingly, the number of farms of less than 50 acres also increased during this period. Although these trends can be observed in all the regions, the changes are not of the same magnitude everywhere.

In the central region, where the largest changes occurred, the percentage of farms in the 50-499 acre category decreased by 21 percentage points during the decade. At the same time an increase of 17 percentage points occurred in the percentage of farms larger than 500 acres. The smallest changes took place in the northeast region, where no category changed by more than 6 percentage points.

Value of land and buildings

For the state as a whole, the value of land and buildings per farm in-

Table 1. — Number and Size of Farms and Acreage in Farms by Crop Reporting Region, 1964-1974

Region	No. of farms		Land in farms, acres		Av. farm size, acres	
	1964	1974	1964	1974	1964	1974
Illinois	132,825	115,059	29,957,500	28,759,722	225	250
Northwest	19,303	16,173	4,121,683	3,991,389	213	231
Northeast	14,073	11,322	2,910,778	2,667,593	207	227
West	12,910	11,323	3,136,969	3,021,346	243	276
Central	13,614	12,195	3,531,833	3,460,804	259	293
East	12,505	11,311	3,364,024	3,358,598	269	301
West-southwest	17,867	16,180	4,155,657	4,017,338	233	259
East-southeast	19,418	17,111	4,119,018	3,930,406	212	259
Southwest	12,354	10,921	2,448,550	2,295,412	198	213
Southeast	10,778	8,793	2,168,998	2,007,886	201	237

Michael Bowling is a research assistant and J. C. van Es an associate professor in rural sociology. The present research was performed through ISEIRD (Illinois Social and Economic Indicators for Rural Development). The authors would like to thank Andrew J. Sofranko, associate professor of rural sociology, who provided the basis for this analysis with a similar comparison of the 1964 and 1969 Censuses in the Fall, 1973, issue of *Illinois Research.*

creased over the decade, with the greatest upsurge coming between 1969 and 1974. A good deal of this increased value is due to inflation. However, a substantial increase (19 percent) in value remains even after the 1974 value is deflated to 1964 levels (Table 3). The increasing importance of Illinois agriculture in the national and international economy is reflected in this increased value.

Although average value of land and buildings showed large increases in all regions over the decade, there was substantial regional variation. The southwest and southeast regions were well behind the other regions in 1964 and became even more so in 1974 despite the increases. The greatest increase in value of land and buildings was in the northeast, central, and east regions. When 1974 prices are deflated to 1964 values, increases are still evident in all regions, with the largest in the northwest (25 percent) and the smallest in the west-southwest (14 percent).

Table 3. — Average Value of Farmland and Buildings

Region	Value of land and buildings		Deflated value 1974
	1964	1974	
Illinois	$ 80,894	$214,167	$ 96,589
Northwest	72,642	201,767	90,997
Northeast	124,307	339,083	152,926
West	71,017	195,256	88,060
Central	117,471	320,423	144,511
East	128,253	339,633	153,174
West-southwest	74,694	188,406	84,971
East-southeast	67,376	170,815	77,038
Southwest	41,141	104,909	47,314
Southeast	37,541	101,867	45,942

Ownership and tenancy

The number of farms operated by full owners increased by almost 2,500 during the 10-year period. By 1974, full owners made up 50 percent of all Illinois farm operators (Table 4). Both the number of farms operated by part owners and the number operated by tenants decreased, with the decline in number of tenants being particularly dramatic. Over the 10-year period the proportion of tenants dropped from almost one-third to only one-fifth of all operators.

Table 4. — Tenure Status of Operators by Crop Reporting Region, 1964-1974

Region	Full owners		Part owners		Tenants	
	1964	1974	1964	1974	1964	1974
			percent			
Illinois[a]	41	50	28	30	31	20
Northwest	45	53	17	24	38	23
Northeast	39	45	21	25	40	30
West	60	53	18	29	22	18
Central	29	40	28	32	43	18
East	24	35	29	35	47	30
West-southwest	44	52	28	30	28	18
East-southeast	42	51	40	38	18	11
Southwest	52	57	30	30	18	13
Southeast	54	61	37	32	9	7

[a] In 1964, 54,592 farms were operated by full owners; 37,446 by part owners; and 40,314 by tenants. In 1974, 57,014 were operated by full owners; 34,929 by part owners; and 23,116 by tenants.

Comparing regions, we find that the proportion of operators who are full owners increased in all regions except the west, while the share of tenant operators decreased in all regions. Part owners became a larger proportion of farm operators in every region except the east-southeast and east, where their proportions decreased, and in the southwest, where their share remained at 30 percent.

While the regions show relatively consistent changes in the tenure status of the operators, there are substantial and relatively persistent differences in the "mix" of tenure status of farm operators between regions. In 1974, for example, the southeast counted 61 percent of the farm operators as full owners and 7 percent as tenants, while the east counted 35 percent of the operators as full owners and 30 percent as tenants. In general, the higher the value of land, the higher is the rate of tenancy.

Table 2. — Percentages of Farms in Three Size Groups

Region	Size of farm					
	1-49 A.		50-499 A.		500+ A.	
	1964	1974	1964	1974	1964	1974
			percent			
Illinois[a]	3	10	87	75	10	15
Northwest	3	7	92	81	5	12
Northeast	7	11	84	78	9	11
West	3	9	86	73	11	18
Central	3	7	86	65	11	28
East	4	7	83	74	13	19
West-southwest	4	11	85	72	11	17
East-southeast	3	11	87	74	10	15
Southwest	3	10	89	79	8	11
Southeast	4	12	83	72	13	16

[a] In 1964 Illinois had 3,684 farms in the 1-49 acre category; 92,253 in the 50-499 acre category; and 9,785 in the 500+ category. In 1974 the 1-49 acre category included 9,351 farms; the 50-499 acre category, 72,102 farms; and the 500+ category, 14,900 farms.

Uneven changes

Although regional data reflect state trends, many regional differences in agricultural patterns persist. Students of Illinois agricultural trends should examine state average figures carefully and look for the regional variations.

Hardness of Wood Flooring And Siding

POO CHOW

HARDNESS represents the resistance of wood to indentation, wear, and marring. It is thus an important factor in determining the suitability of a wood material for use where such resistance is needed.

Exterior hardboard siding products are required to have a minimum average hardness of 450 pounds. When particleboard is used as decking in the construction of mobile homes and factory-built housing, it must have a minimum hardness of 500 pounds when air-dry.

It has been reported that the hardness of commercially important wood species increases when the moisture content drops below 30 percent. However, there is no information about the effect of moisture on the hardness of particleboard, hardboard, and solid lumber used by the furniture and home-building industries. A study was therefore initiated to obtain information on this subject.

Test and materials

Specimens about 3 inches by 6 inches were cut from 16 commercial wood products (Table 1), including five species of furniture lumber, five wood floorings, five exterior sidings, and one aluminum siding with a 0.019-inch aluminum face and 5/16-inch insulation board backing. All wood specimens were originally 2 inches thick except the flakeboard, particleboard, and hardboard. These three products were laminated to a thickness of 2 inches with a phenol-formaldehyde adhesive.

Specimens were conditioned and tested at 70°F. under (1) a normal humidity condition of 50 percent relative humidity; (2) a humid condition of 90 percent relative humidity; and (3) a condition simulating rain, which was obtained by soaking the samples for 24 hours. The standard Janka ball test, as specified in American Society of Testing and Materials Standard D-143, was used with necessary modifications for determining hardness values.

Face hardness values

The results of face hardness tests are shown in Table 1. Each value represents the average of eight tests. In solid wood, densities of different species significantly affected the resistance to indentation and wear. Red oak, white oak, and sugar maple flooring had both higher densities and higher hardness values than the five kinds of furniture lumber, the redwood siding, and the cedar siding.

Particleboard floor tile and tempered hardboard flooring were the hardest materials at all three moisture conditions. The aluminum siding with fiberboard backing had the lowest average face hardness value.

The hardness of all specimens decreased as they were exposed to 90 percent relative humidity and then to soaking. This decrease was especially pronounced in southern pine and ponderosa pine lumber, aspen flakeboard, particleboard siding, and aluminum siding with fiberboard backing. When these materials were exposed to humid and wet conditions, they lost more than a third of their normal dent resistance.

The decrease in face hardness of aspen flakeboard and particleboard siding was probably due not only to normal swelling but also to springback. These two things decreased the panel density and weakened the bonds among the wood particles on the surfaces of the boards.

Humid and wet conditions had the least effect on the redwood and cedar sidings. Three species of furniture lumber (walnut, silver maple, and Douglas fir), all of the wood floor materials, and the hardboard sidings also held up well.

Even after exposure to 90 percent relative humidity, all the hardboards and particleboards in the test had hardness values above the minimum standards for these materials.

Table 1. — Average Face Hardness of Wood Panels at Two Relative Humidities and After Soaking (Temperature 70°F.)

Type of panel	Density, lb. per cu. ft.[a]	50% rel. humidity: Hardness, lb.	50% rel. humidity: Moisture content, pct.[b]	90% rel. humidity: Hardness, lb.	90% rel. humidity: Moisture content, pct.[b]	24 hr. in water: Hardness, lb.	24 hr. in water: Moisture content, pct.[b]
Furniture lumber							
Walnut	33	1055	7.5	970	17.5	800	35.0
Silver maple (soft)	30	1010	8.5	740	18.5	730	40.0
Douglas fir	32	610	8.9	560	19.0	370	42.0
Southern pine	34	815	9.0	490	20.0	355	48.0
Ponderosa pine	25	475	8.5	350	20.0	265	45.0
Wood flooring							
Sugar maple (hard)	37	1460	8.7	1360	19.0	1300	35.0
Red oak	40	1760	8.5	1655	18.0	1210	36.0
White oak	41	1560	8.0	1365	17.6	1100	33.0
Particleboard tile (d.f.)	51	2150	5.0	1900	12.0	1800	17.5
Tempered hardboard	65	2345	3.5	2100	9.0	1800	9.0
Exterior siding							
Redwood	28	420	7.5	410	19.5	405	29.0
Cedar (Weston red)	30	350	8.0	330	20.0	320	32.0
Aspen flakeboard	43	820	6.0	550	17.0	280	43.0
Hardboard (primed face)	45	1610	4.5	1380	9.0	1360	10.5
Particleboard (primed face)	43	1125	5.5	850	12.5	460	17.0
Aluminum (fiberboard back)	24	165	5.0	100	16.0	85	26.0

[a] Based on oven-dry weight and air-dry volume. [b] Moisture content based on oven-dry weight.

Poo Chow is associate professor of wood science, Department of Forestry.

How Illinois Farmers View Farm and Food Policy Issues

HAROLD D. GUITHER

ILLINOIS FARMERS support the principle of a market-oriented farm policy, yet in times of financial stress and overproduction, they would like some type of government assistance. This is the conclusion to be drawn from a survey made in November and December after the 1976 election.

A sample of 1,500 farmers was drawn by the Illinois Cooperative Crop Reporting Service. Survey questions were prepared in the Department of Agricultural Economics in cooperation with the Illinois Agricultural Experiment Station and the Cooperative Extension Service. The questionnaires were mailed the week after election day. Completed questionnaires were received from 460 farmers from throughout the state.

Role of government

Farmers responding to the survey favored a minimum of government involvement in their farming operations. An overwhelming 86 percent agreed with the statement: "Let farm market prices move up and down without direct government interference to guide farmers in their production decisions." At the same time, however, 50 percent agreed with this statement: "The government should continue to use tax revenues to keep farmers' prices and incomes from dropping to low levels during times of large supplies."

Since the 1973 Agricultural Act expires at the end of 1977, farmers were asked what they thought Congress should do about future farm legislation. A majority of 55 percent believed the 1973 Act should be kept in its present form but should be revised by raising target and loan prices closer to costs of production. However, 24 percent wanted to eliminate all government price and income support programs. Another 8 percent said to keep the present law as it is, extending it for another period of years. Only 3 percent wanted to let the law expire and go back to earlier price and income support laws. The remaining 10 percent had no opinion or alternative suggestions.

Since acreage set-aside programs were a basic part of price and income support programs in 1973 and earlier years, farmers were asked their views on such programs. In response, 45 percent said that they wanted the set-aside program to be available if needed. However, 32 percent opposed set-aside programs.

As a replacement for set-aside acres, 19 percent favored a government-financed storage program by which farmers would store grain from a specified acreage. Such grain could not be sold unless supplies were short and prices rose above a certain point. Senator Bellmon of Oklahoma has introduced a bill to establish this program and Secretary of Agriculture Bergland has spoken favorably of the proposal.

Target prices and loan rates

Since target prices were a key part of the 1973 Act, farmers were asked to make their recommendations for 1977. For corn, these averaged $2.22 compared to $1.57 in 1976; and for wheat, $3.06 compared to $2.29 last year.

Farmers were also asked on what basis target prices should be established. The current method received the most responses. About 46 percent would start with current target prices, and adjust them each year for changes in the prices that farmers must pay for production items, including labor and interest rates. However, 10 percent would use an average cost of production, including average land costs, for the major producing area. Only 9 percent suggested use of the parity principle of equal purchasing power for farmers calculated from the 1910-14 base period adjusted for recent changes.

Loan rates under the 1973 Act were set at low levels so they would not influence market prices or cause stocks to accumulate under government ownership. Illinois farmers would like to see higher loan rates in 1977. For corn, their recommendations average $1.99, for wheat $2.75, and for soybeans $4.11. The 1976 rates were $1.50 for corn, $2.25 for wheat, and $2.50 for soybeans.

Despite the suggestions for higher loan rates, these same farmers do not favor government ownership of grain reserves. Only 27 percent agreed with the statement, "To stabilize farm and food prices and supplies, the government should hold some grain reserves. It should buy when prices are low and sell when they are high." Sixty-six percent disagreed, and 7 percent had no opinion. These responses suggest that farmers would like higher loan rates but not so high that the government accumulates stocks to be sold during periods of reduced supplies and high prices.

Restrictions on exports of farm products in 1973, 1974, and 1975 were alarming to farmers. In response to the statement, "The government should not restrict farm and food product exports under any circumstances," 57 percent agreed, 35 percent disagreed, and 8 percent had no opinion.

Some inconsistency also shows up in responses to questions about export agreements. For example, 65 percent felt that the United States should not have any export agreements, but

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should just let each country buy commodities as it needs them and as we have them available. Yet 69 percent felt that the agreements requiring Russia to buy at least 6 million tons of grain and allowing it to buy more was in the best interests of farmers. Also 69 percent favored setting up export agreements with major buyers to assure a steady market for farmers and a stable supply for our consumers.

In response to another statement, 60 percent favored an agreement to sell Japan all that it wants to buy.

Food assistance

Farmers are more divided in their views about food aid programs both in this country and overseas.

In response to the statement, "The government should use tax funds to help buy food for our people with low incomes," 56 percent agreed, 32 percent disagreed, and 12 percent had no opinion. When asked if the food stamp and other government food assistance programs in this country helped strengthen U.S. farmers' markets, 43 percent felt they did, 40 percent did not think so, and 17 percent had no opinion.

In recent years, under Public Law 480, our government has distributed about 5 percent of our farm and food exports to low income countries for credit at reduced interest or as gifts. Under present world market conditions, 43 percent felt we should discontinue all such assistance, 44 percent believed we should continue it, and 13 percent had no opinion.

However, Illinois farmers do have a humanitarian concern for people in need. Although many would question other forms of food aid, 63 percent agreed that we should provide food aid to countries suffering from disasters such as drouth, floods, or earthquakes.

Characteristics of respondents

The Illinois farmers responding to the survey represent all parts of the state, all age groups, and all types and sizes of farms. About 20 percent of the farmers were under 40, 53 percent were between 40 and 59, and 27 percent were 60 and over. Grain was the most important source of farming income for 65 percent; about half grain and half livestock for 18 percent; hogs and beef cattle for 9 percent; dairying for 5 percent; and other sources for 3 percent.

The average number of acres farmed was 400. About 58 percent of the respondents farmed less than 340 acres, 25 percent between 340 and 649 acres, 13 percent between 650 and 1,199 acres, and 4 percent 1,200 acres or over. With these farming operations, 38 percent reported working off the farm at another job during 1976.

The formal schooling received by respondents also varied: 19 percent completed elementary school only; 12 percent had some high school; 43 percent completed their formal education with graduation from high school; 15 percent attended college without graduating; and 11 percent graduated from college.

Organization affiliations also varied. Among those responding, 75 percent were Farm Bureau members; 3 percent were Farmers Union members; 1 percent belonged to the Grange; 3 percent to the National Farmers Organization, 14 percent to the Pork Producers, 6 percent to the Livestock Feeders, 6 percent to the Milk Producers, 7 percent to the Corn Growers, 20 percent to the Soybean Association, and 9 percent to a labor union.

When responses to the questions were cross-tabulated with the various characteristics of farmers, no major differences were found. Age, size and type of farm, education, and organizational affiliations may have caused some slight differences in the farmers' responses to questions about farm policy issues. But these differences could be explained as much by variations in sampling as by differences in personal and farming characteristics.

About the same time that the Illinois farmers were surveyed, a similar survey was made in Indiana. The Indiana farmers expressed opinions and attitudes very similar to those of their counterparts in Illinois.

Funk Awards

In the seventh annual Paul A. Funk Recognition Program, held on March 4, five College of Agriculture staff members received citations and cash awards for "outstanding performance and high achievement." The funds for this program are provided by the Paul A. Funk Foundation of Bloomington.

Brief summaries of the winners' major achievements are given in the following paragraphs.

David Hiram Baker

Dr. Baker is an internationally known authority on the comparative nutrition of swine and poultry.

His studies of the energy and amino-acid requirements of gestating gilts and sows have demonstrated that protein levels in swine rations can be reduced without impairing reproductive efficiency. These studies have also shown that part of the soybean meal may be replaced with synthetic sources of amino acids at substantial savings to pork producers.

Other significant research conducted by Dr. Baker and his associates includes the role of dietary inorganic sulfate and the hydroxy analogue of methionine upon the methionine and cystine nutrition of nonruminant animals; the efficacy of tryptophan in meeting dietary niacin needs; and the availability of phosphorus and nitrogen from the nucleic acids in single-cell (yeast) proteins.

He received a Research Excellence Award from the American Society of Animal Science in 1971 and the American Feed Manufacturers' Nutrition Research Award in 1973. As a teacher, he is noted for his exceptional ability to motivate students and to make complex concepts understandable. He is the author of numerous articles, one of which appears in this issue of ILLINOIS RESEARCH.

. . . Five Winners Are Announced

James Wessel Gerdemann

Dr. Gerdemann is noted for his work on soil-borne root-infecting fungi and is an international authority on the taxonomy of the endomycorrhizal fungi.

He has discovered an important new genus of root-rot fungi on legumes, and his investigations of Phytophthora root and stem rot of soybeans have accelerated the development of resistant varieties.

He was the first scientist to identify the spores of endomycorrhizal fungi in agricultural soils and to develop methods for propagating and studying them. His research showed the importance of these fungi in the uptake of essential nutrients and their translocation through the soil to plant roots. He further demonstrated that the stunting of citrus plants growing in fumigated soil was due to nutrient deficiencies resulting from the absence of endomycorrhizal fungi. Similar problems have now been recognized in other crops.

In recognition of his research accomplishments, Dr. Gerdemann was elected a Fellow of the American Phytopathological Society in 1975. His ability as a teacher is attested to by the fact that in 1976 he was one of only four recipients of the University of Illinois Award for Excellence in Undergraduate Teaching.

Lester Touby Kurtz

Dr. Kurtz's research on phosphorus and nitrogen soil chemistry has earned him world-wide recognition.

With Dr. R. H. Bray, he developed the P-1 and P-2 tests for determining available phosphorus in soils, and he has developed other widely used "quick tests" for different soil elements. His extensive research in the chemistry of soil phosphorus has resulted in more efficient use of phosphorus fertilizers and in substantial yield increases.

He was one of the first investigators to use isotopically labeled nitrogen in field experiments. These experiments have contributed significantly to our knowledge of nitrogen uptake by plants, the residual value of nitrogen fertilizers, the environmental effects of nitrogen fixed by legumes, and nitrogen balance in relation to management.

Dr. Kurtz has served as a consultant to universities in Australia, India, Egypt, and West Africa. He was elected a Fellow of the American Association for the Advancement of Science in 1949 and of the American Society of Agronomy in 1966. He has also been awarded Fulbright and Guggenheim Foundation Fellowships, and was recently a Lady Davis Fellow in Haifa, Israel.

Fay Montrose Sims

Professor Sims has achieved national prominence for his leadership in farm management extension, the economics of farm production, and the development of farm income tax schools.

Under his direction, the Illinois Farm Income Tax School Program has grown from six schools and 471 participants in 1961 to 41 schools and more than 3,600 participants in 1976. The Illinois program is now used as a model in 11 other states. For his "exceptional service" in helping these states establish their tax schools, Professor Sims received an Award of Commendation from the President of the United States in 1970.

As head of the Test Demonstration Farm Program from 1960 to 1975, he worked with selected farm families in demonstrating advanced methods of farm management. This interdepartmental project, held in cooperation with the Tennessee Valley Authority, has resulted in higher crop yields, more efficiently operated livestock enterprises, and better living conditions on the cooperating farms, as well as other farms in the test areas.

Professor Sims has received outstanding achievement awards from both the American and the Illinois Societies of Farm Managers and Rural Appraisers, and the College of Agriculture Alumni Award of Merit.

Earl Raymond Swanson

One of the nation's outstanding agricultural economists, Dr. Swanson has demonstrated a unique ability to coordinate and lead research involving scientists from other disciplines. He has also been a leader in applying principles of production economics to farm management, soil and water conservation, and alternatives in the area of environmental quality.

Dr. Swanson was one of the first agricultural economists to use linear programming for solving agricultural problems. He has also developed techniques for integrating cropping and livestock systems; demonstrated the impacts of various soil fertility programs on the farm enterprise; and proposed ways of applying experimental results to actual farm operations.

In addition to his significant research accomplishments, Dr. Swanson is a dedicated teacher, and has served as associate head and as acting head of the Department of Agricultural Economics. In 1968 he received a commendation from the American Agricultural Economics Association for his editorship of the *American Journal of Agricultural Economics*; in 1975, an Ernest H. Wakefield Award from the University of Illinois for outstanding professional achievement; and in 1976, a College of Agriculture Alumni Award of Merit.

FARM BUSINESS TRENDS

INFLATION has had a strong impact not only on farm product prices, costs, and incomes, but also on assets in agriculture and on debts.

Farm prices began to rise in 1972 and increased sharply in 1973 (Fig. 1). Costs rose less sharply, so that net farm income for 1973 was a record $29.9 billion. Since then, farm prices have tended to level off while costs have continued to rise.

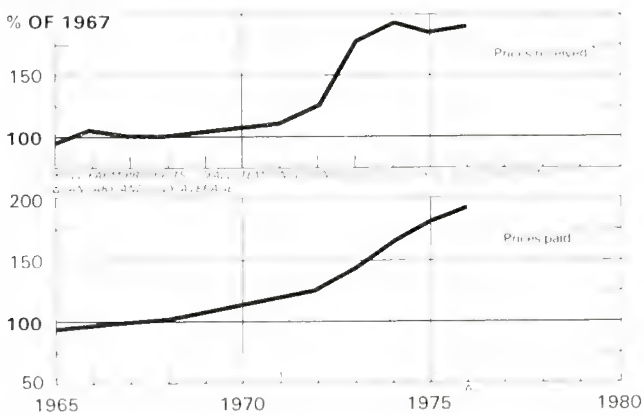
With this price and income situation, assets in agriculture rose from $306.2 billion on January 1, 1970, to an estimated $634 billion on January 1, 1977. Indebtedness increased from $53.0 billion to $101.6 billion, or 92 percent. Real estate debt increased from $29.2 billion to $56.7 billion for a 94-percent increase. Non-real estate debt more than doubled, going from $21.2 billion to $44.4 billion.

Sources of credit for agriculture have changed somewhat in relative importance. For real estate, individuals have traditionally been the largest source of credit. They continue to hold the leading position, but by very little. In 1970, individuals held real estate loans amounting to $11 billion; on January 1, 1977, the figure was $19.9 million, or 82 percent more. A close second in real estate loans on January 1, 1977, was the Federal Land Banks, with loans of $18.7 billion. This was an increase of 180 percent from $6.7 billion on January 1, 1970. Changes in regulations have enabled the Federal Land Banks to expand their volume of business. The proportion of real estate loans held by life insurance companies has declined substantially. In 1970 they had accounts of $5.7 billion, but by 1977 they had increased only 32 percent, to $7.6 billion.

For non-real estate loans, the major lenders are banks. Their loans increased 118 percent, from $10.3 billion in 1970 to $22.5 billion on January 1, 1977. This is slightly more than half of the total $44.4 billion non-real estate debt. The largest percentage growth among major sources of non-real estate credit was in the production credits associations, whose loans increased 177 percent, from $4.5 billion to $12.4 billion. The smallest growth was in the miscellaneous category of individual merchants and dealers.

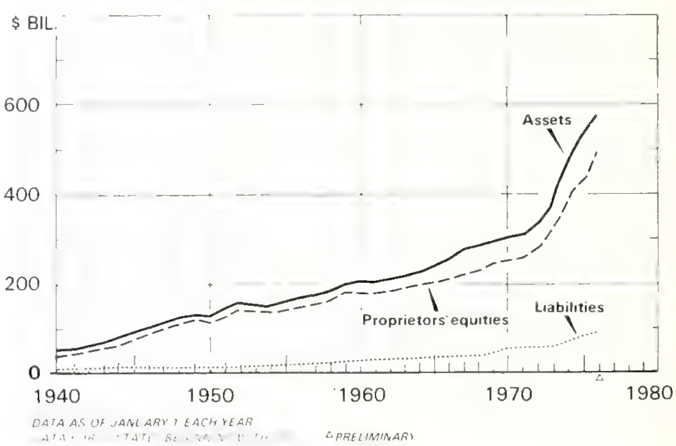
The debt-to-asset ratio has not changed sharply. In the early 1960's it was about 13 percent; by the early 1970's it was slightly over 17 percent; and for the mid-70's it has averaged about 15.5 percent. — *M. B. Kirtley, Extension Economist, Livestock Marketing*

FARMERS' PRICES



Prices received and paid by farmers, 1965-1976. **(Fig. 1)**

BALANCE SHEET OF THE FARMING SECTOR



Farmers' assets and liabilities, 1965-1976. **(Fig. 2)**

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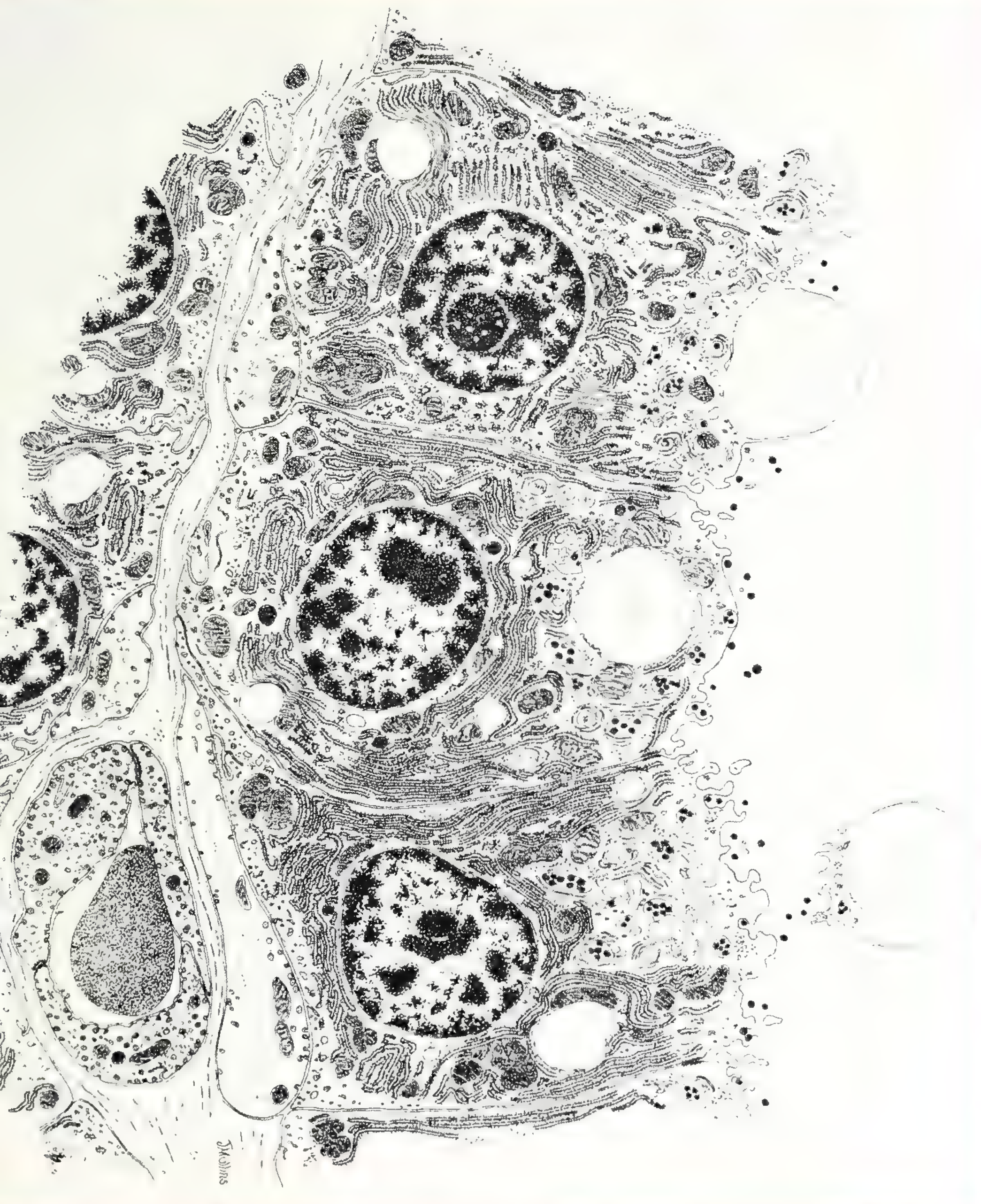

Three secretory cells in cow's mammary tissue, greatly enlarged. Such cells are being studied to learn more about the way in which cows produce milk (page 10).

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THE SIGNIFICANCE OF TITLE XII

AS THE RESULT of an act signed into law by President Ford in December, 1975, the nation's land-grant universities will be participating as never before in helping to solve the problem of world hunger. The law is the Foreign Assistance Act of 1975, which contains Title XII, the Famine Prevention and Freedom From Hunger Act. It provides:

> The United States should strengthen the capacities of the United States land-grant and other eligible universities in program-related agricultural institutional development and research, . . . should improve their participation in the United States government's international efforts to apply more effective agricultural science to the goal of increasing world food production, and in general should provide increased and longer term support to the application of science to solving food and nutrition problems of the developing countries.

A December, 1976, circular letter from the Office of the Executive Director of the National Association of State Universities and Land-Grant Colleges states, "Title XII may be the most significant piece of legislation to respond to the world's most pressing problem since the passage of the Morrill, Hatch, and Smith-Lever Acts."

In the same letter, the Association's Executive Director Ralph H. Huitt writes, ". . . It is safe to say that never before has an organized state put such a burden for carrying out national policy on institutions of higher education as the United States does here, and never before has the credibility of a certain kind of institution and its mode of operations been required to stand so severe a test. The government has said in effect: 'All right, you have proved you can teach Americans how to feed themselves. Now prove you can teach the people of the world how to feed themselves.' "

As authorized by the legislation, President Ford appointed a Board for International Food and Agricultural Development in August, 1976. One of the seven members on the board is Dean Orville G. Bentley of the University of Illinois College of Agriculture. The board has been meeting regularly since last October to plan strategies for reaching the high goals set forth in Title XII. — *W. D. Buddemeier, Director of International Programs*

Thatch as a Turfgrass Growing Medium

A. J. TURGEON, K. A. HURTO, and L. A. SPOMER

In many turfgrass areas, a distinct layer of thatch lies between the soil and the zone of green vegetation. Living and dead stems, leaves, and roots are tightly intermingled to make up this layer (Fig. 1).

A small amount of thatch may be desirable because it improves the wear tolerance of the turf, and it insulates the soil against temperature extremes. Excessive thatch accumulation, however, makes the turf more susceptible to disease and insect problems, and to heat, cold, and drouth stresses.

Turf profile with thatch layer between soil surface and vegetation. (Fig. 1)

How thatch develops

Thatch forms when organic debris from the actively growing turf accumulates faster than it decomposes. According to studies at the University of Illinois and elsewhere, cultural or environmental factors that stimulate excessive growth or impair decomposition are conducive to thatch development.

The actual sequence of events leading to the formation of thatch is not clear. Presumably, a relatively stable layer of organic material accumulates at the soil surface from clippings, senescent leaves, and aboveground adventitious rooting.

The turfgrass plants apparently respond by forming crowns, highly compressed stems at the base of aerial shoots, within this organic layer. (In a thatch-free turf, crowns form at or below the soil surface.) Adventitious roots and rhizomes emerge from mature sections of the crowns and start growing in the organic material.

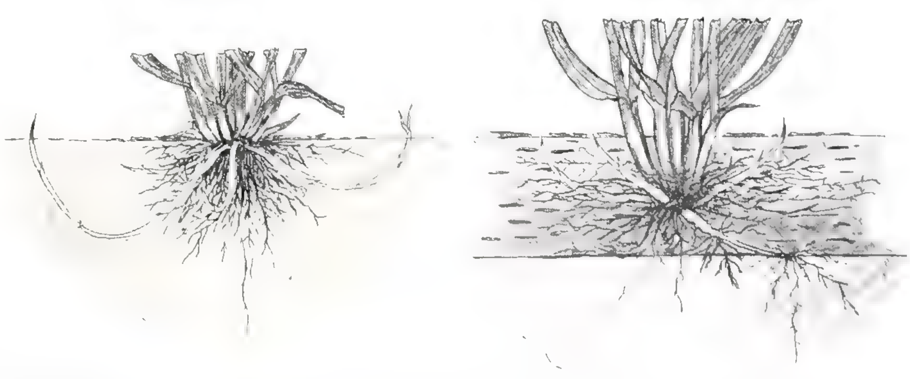
Some of the crowns that develop in the thatch likely result from continued vertical growth of existing crowns. Others are formed by emerging rhizomes after they have been exposed to light and cease internode elongation. Since the thatch keeps light from penetrating to the soil surface, the internodes do not stop elongating until the rhizome terminal grows up to a level near the surface of the thatch.

As the older shoots and roots die, the crowns, roots, and rhizomes may eventually grow mostly within the thatch rather than in the soil (Fig. 2). Thus, where a substantial thatch has developed, it can constitute the primary growing medium for the turfgrass plants while the underlying soil is of only secondary importance. It is therefore important to characterize thatch as a growing medium in order to get the best results from cultural practices.

Thatch characteristics

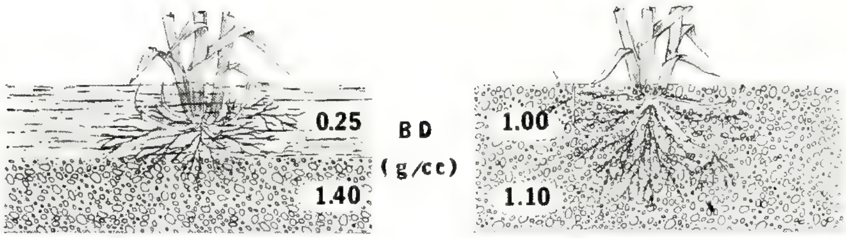
Thatch typically has a lower bulk density than either the underlying soil or the surface soil from a thatch-free turf (Fig. 3). Since the soil underlying thatch contains few roots or rhizomes, it tends to be more compacted than thatch-free soils in which these organs grow extensively. This illustrates the favorable effects of root and rhizome growth on soil physical conditions.

The thatch layer may contain appreciable amounts of soil. Much of the soil may have been carried by earthworms to the turfgrass surface during the spring and fall. In intensively cultured turfs, soil can also accumulate in the thatch as a result of topdressing, core cultivation, and vertical mowing operations. The effects of incorporating soil into the thatch are currently under study. According to preliminary results, the addition of soil apparently increases bulk density of the thatch substantially. The soil also reduces the mobility of surface-applied fertilizer nutrients and pesticides. Since thatch is typically regarded as an organic medium that is essentially devoid of soil, the inclusion of soil in thatch results in a "hybrid" entity with entirely different physical and chemical properties (Fig. 4).



Distribution of roots, rhizomes, and crowns in thatch-free turf (left) and thatchy turf (right). (Fig. 2)

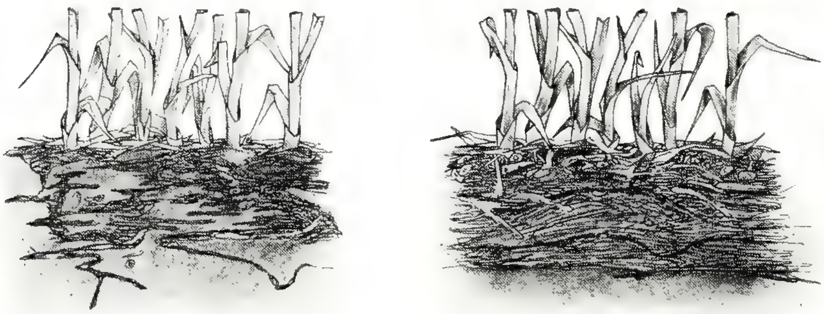
A. J. Turgeon is associate professor of turfgrass science; K. A. Hurto, research assistant; L. A. Spomer, associate professor of plant physiology.



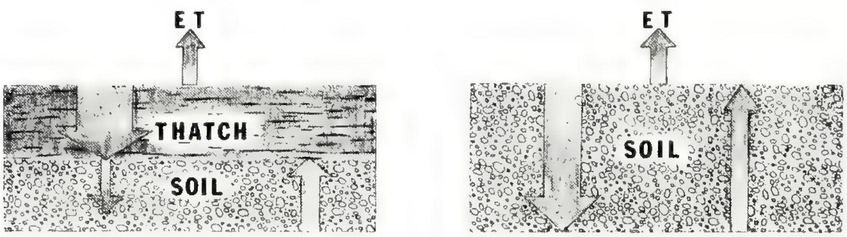
Bulk densities of thatch (left), the underlying soil, and soil from thatch-free turf (right). (Fig. 3)

Comparison of thatch and soil as turfgrass growing media:

	Thatch	*Soil*
Aeration:	Good	Fair to poor
Compaction:	Resistant	Susceptible
Moisture retention:	Poor	Good
Nutrient retention:	Poor	Good



Pure thatch (right) and a "hybrid" form (left) resulting from incorporation of soil into the organic material. (Fig. 4)



Impact of thatch on turfgrass-water relations. Disruption of capillary pore continuity halts upward water movement at the thatch-soil interface. (Fig. 5)

Physically, thatch is analogous to sand in that it has large pores. This property means that thatch has better aeration than most soils, as well as better resistance to compaction under traffic (Fig. 5).

However, the large pores readily lose water from drainage into the underlying soil and evapotranspiration into the atmosphere. An additional problem is that upward water movement stops at the thatch-soil interface, where the continuity of capillary pores is disrupted.

Irrigation and fertilization

Because of the poor water-holding capacity of the thatch, and also because of restricted rooting, thatchy turfs are especially prone to wilting during long drouths. When completely dry, thatch repels water and is extremely difficult to re-wet. Consequently, thatchy turfs need more irrigation than thatch-free turfs.

The frequent waterings required on thatchy turf tend to leach nutrients and pesticides through the thatch, so these materials have to be applied oftener than on a thatch-free turf. Intensifying this need is the low nutrient storage capacity, or cation exchange capacity (CEC), of thatch. This low CEC does not show up if thatch is compared with soil on a weight basis. In fact, thatch samples had CEC measurements nearly twice those of equal weights of a silt loam soil. However, when these values were compared on an equal volume basis, the CEC of thatch was substantially lower than that of soil.

Another problem associated with fertilization of thatchy turf occurs because soil-testing laboratories routinely discard the thatch before testing samples from turfgrass sites. Since most of the grass root system is in the thatch, the value of test results in determining fertilizer requirements is questionable. A valid test should include the thatch as part of the soil sample, or a separate analysis should be conducted for the thatch alone.

Controlling thatch

In attempts to control thatch, various cultivation methods for extracting part of the organic debris without completely destroying the turf have been tried. These methods usually are not completely effective; they often injure the grass severely; and their beneficial effects may not last beyond one or two growing seasons.

However, one cultivation method, called coring or core cultivation, does alleviate soil compaction and improve infiltration in thatchy turfs. Small cores of soil are extracted to a depth 2 or 3 inches below the turf and are then dispersed and dragged into the turf, becoming part of the thatch layer. Although the thatch is not reduced uniformly through the turf, the thatch's physical and chemical properties are apparently modified. As a result, more moisture and nutrients are retained, and fewer fertilizer and irrigation applications are needed. Thus this practice can conserve natural resources as well as improve turf quality.

A New Kind Of Virus Is Discovered

ROBERT M. GOODMAN

It is exciting to be involved in the discovery of something radically new, especially when the discovery is unexpected and has practical implications. Recent studies in my laboratory in the Department of Plant Pathology resulted in such a discovery in 1976.

At the time, we were studying one of several plant diseases transmitted by the tropical whitefly, *Bemisia tabaci.* For years, important cash crops in tropical and subtropical areas have been afflicted by these diseases. Symptoms range from curling and other malformations to bright yellow mosaic patterns on leaves. Since these symptoms are usually associated with viruses, plant pathologists assumed that the diseases were of viral origin. The actual causal organisms, however, remained unknown, despite attempts by two generations of workers to learn more about them.

A major obstacle was that the pathogens were transmissible only by the whitefly, and could not be transferred to healthy plants by mechanical inoculation. In the early 1970's, however, several scientists in tropical America and Africa succeeded in mechanically transmitting pathogens causing diseases of beans and of cassava. This was the breakthrough that was needed for studies on the nature of the pathogens.

Discovery of virus

In cooperation with Dr. Julio Bird of the University of Puerto Rico Agricultural Experiment Station, we began studying the bean golden yellow mosaic disease in 1975. The diseased plants are grown in an isolated growth chamber maintained at a high temperature (90°F.) and high humidity (90 percent). As we quickly discovered, efficient mechanical transmission and rapid disease development depend upon these conditions. The inoculum is prepared from plants within a few weeks after they themselves have been inoculated. Old plants, even when severely infected, are not a good source of inoculum for passing on the infection.

Before we could be satisfied that the disease was caused by a virus, we needed to isolate the virus in pure form and then produce the disease in healthy plants by inoculating them with the virus. This requires rather sophisticated techniques because viruses are so extremely small.

We soon discovered a virus-like particle in infected beans. But when viewed in the electron microscope, the particles were very much smaller than typical viruses, and seemed to be mostly in pairs. We still do not know the significance of the pairing, but results of plant inoculations proved that this unusual looking virus was indeed the cause of bean golden yellow mosaic.

Virus differs from others

The big surprise was to come later, when we were trying to learn whether the new virus was in some way related to any known viruses. This information is important in understanding where economically important viruses come from in the field.

The approach we followed was to determine the type of nucleic acid contained in the virus, because the nucleic acid carries the genetic information that allows the virus to cause a disease. All viruses contain either DNA or RNA, each of which comes either as a single-stranded (ss) or a loosely bonded double-stranded (ds) molecule. Before our work, all known plant viruses contained either ds-DNA or ss- or ds-RNA, with the vast majority containing ss-RNA.

Our virus turned out to be the first plant virus discovered that contains ss-DNA. It was not related to any other known plant virus and appeared to represent an entirely new class of plant-pathogenic viruses. Subsequent work in our laboratory and in Puerto Rico, Scotland, and Kenya indicates that there are probably other viruses in this new class. Studies are now under way to characterize them and work out their possible relationships.

Practical significance

Probably the most important mission of the plant pathologist is to help growers control diseases. While no virus of this new group has as yet been reported in the United States, the whitefly vector does occur in the southern states. With our knowledge of these new viruses, we can be on the lookout for them and try to keep them out of the country.

By purifying the virus, we can prepare a specific antibody that will react in specialized tests only with the virus and its relatives. These tests can be used in the field to find and eliminate reservoir hosts — perhaps weeds or other wild vegetation — from which the virus spreads via the whitefly to crops.

At present the greatest benefits from our work can be expected in areas where most of the world's hungry people live. These are the areas that are plagued by the group of plant diseases we are studying. Bean golden yellow mosaic, for example, is the major bean disease in some parts of tropical America where beans are an important dietary staple. In Sri Lanka and parts of India soybean and mung bean yields are seriously reduced by the whitefly-transmitted mung bean yellow mosaic virus. On the basis of our work, it may now be possible to breed new varieties that are resistant to these diseases.

Robert M. Goodman is assistant professor of plant pathology and of international agriculture (INTSOY). Others involved in studies reported here were J. Bird, University of Puerto Rico Agricultural Experiment Station; and Pornpod Thongmeearkom, graduate student, and Teresa L. Shock, assistant plant pathologist (INTSOY), University of Illinois. Research was supported by the Illinois Agricultural Experiment Station and the International Soybean Program.

Purslane Sawfly Helps Control Common Purslane

S. F. GORSKE, H. J, HOPEN, and R. RANDELL

The adult male purslane sawfly (right) can be distinguished from the female by its forked antennae.

Now considered an objectionable weed, purslane (*Portulaca oleracea*) was once cultivated for food. As such, it was an early immigrant to America, arriving from either Europe or Asia about 300 years ago. According to reports dating from the late seventeenth century, it was being cultivated at that time in Massachusetts.

Because purslane is so prolific, it spread rapidly through the country, thriving on rich, moist soils. It has now become a major pest in vegetable fields, orchards, ornamental nurseries, and now even some soybean and grain fields, where it competes for water, nutrients, and, to a lesser degree, light and space.

Purslane is difficult to control. It often escapes herbicide treatment because it doesn't germinate until soil and air temperatures are high, and by that time herbicides may be dissipated. Cultural practices may be ineffective because an uprooted purslane plant can send out adventitious roots and re-establish itself without suffering much damage.

Fortunately, another immigrant to America can control common purslane at least partially and sometimes completely. This immigrant is the purslane sawfly (*Schizocerella pilicornis*). We don't know just when it was introduced to this country, but it probably arrived at some time with a purslane plant.

The purslane sawfly was first studied in 1898, when it was generally distributed over Ohio and probably other states. Currently it can be found from Florida to Texas and north to Montana and Minnesota. It has also been identified in Mexico, Argentina, Bolivia, Uruguay, Venezuela, and Jamaica, and now occurs in Australia, where it was accidentally introduced from the United States.

In central Illinois the adult purslane sawfly can be seen flying around purslane plants from May to September. The male adult can be identified by his forked antennae; the female's antennae are not forked.

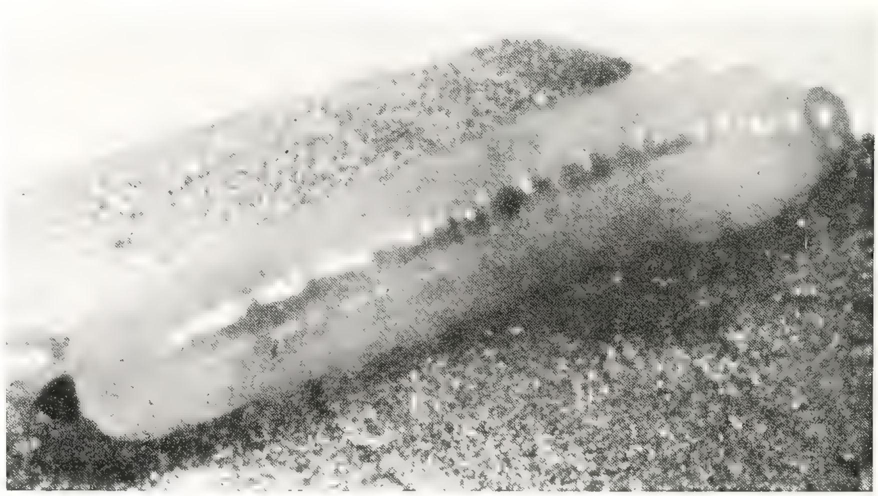
Life cycle

Before ovipositing, the female examines the purslane leaves and selects the healthiest ones. She lays her eggs in the edges of the leaves, being cautious to lay only one egg per leaf. As the egg develops, it resembles a small blister. Larvae hatch from the eggs after about 80 hours.

There are two types of larvae: One is a leaf miner which will mine out the leaf, leaving only the cuticle intact. After devouring one leaf, it emerges, crawls over to another, and begins its mining all over again. The second type of larva feeds only from the outside of the leaf. It will eat about twice as much as the leaf miner.

The two types of larvae are identical in appearance except that the externally feeding larva is bigger. However, there are large genetic differences between the two types, according to electrophoretic experiments on four enzyme loci.

The larval stage lasts about 130 hours, after which the larvae crawl down the plant to the ground, where they tunnel into the soil to a depth of 2.5 to 5.0 centimeters (1 to 2 inches). There the larvae spin silken cocoons, to which tiny bits of soil and sand adhere. About 200 hours later the adults emerge, mating occurs, and the female begins to lay eggs. The adults live only about 24 hours and do not feed; egg laying is



Larva feeding on the outside of a purslane leaf.

S. F. Gorske is research assistant in horticulture; H. J. Hopen, professor of vegetable crops; R. Randell, assistant professor of agricultural entomology.

their sole purpose. In central Illinois the sawfly undergoes six to seven generations in a single season.

The sawflies overwinter as pupae in the soil at the base of purslane plants. Fall and spring plowing destroys a high percentage of these overwintering larvae. The survivors are mostly those that overwinter in the aisle ways and fencerows. As a result, the population is slow to build up in the spring and the first and second generations are very small. Late in the third generation some control of purslane is noticeable, and by the fourth generation, most of the purslane is stripped of its leaves.

Feeding and pesticide tests

The purslane sawfly is a very specific feeding insect. In starvation tests, it fed on only two plant species. These were *Portulaca oleracea* (common purslane), the major host plant in the Midwest; and *Montia perfoliata* (miner's lettuce), which is a close relative of *P. oleracea*.

Included in these tests were major representatives of the *Portulacaceae* family (Table 1). Sixteen other plants were also tested for larval feeding, including the major broadleaf and grassy weeds of central Illinois and several economic plants that are usually grown where purslane is found. The larvae did not feed on any of these plants, and consequently died. The 16 plants were:

- Red root or rough pigweed (*Amaranthus retroflexus*)
- Velvet leaf (*Abutilon theophrasti*)
- Jimson weed (*Datura stramonium*)
- Cocklebur (*Xanthium pennsylvanicum*)
- Ivy-leaved morning glory (*Ipomoea hederacea*)
- Common ragweed (*Ambrosia artemisiifolia*)
- Prickly sida (*Sida spinosa*)
- Prostrate spurge (*Euphorbia supina*)
- Carpetweed (*Mollugo verticillata*)
- Pennsylvania smartweed (*Polygonum pennsylvanicum*)
- Lambsquarter (*Chenopodium album*)
- Yellow foxtail (*Setaria lutescens*)
- Tomato (*Lycopersicum esculentum*)
- Cotton (*Gossypium neglectum*)
- Peas (*Pisum sativum*)
- Lettuce (*Lactuca sativa*)

Table 1. — Effects of Purslane Sawfly Larvae on Plants From Portulacaceae Family

Plant	Effect of larvae
Portulaca oleracea (common purslane)	Egg laying and complete defoliation
Stems only	Some feeding but not enough to support life
Portulaca grandiflora (moss rose)	Some minor cuticle scratching
Portulaca pilosa	No feeding
Portulaca spp. unknown	No feeding
Montia perfoliata (miner's lettuce)	Egg laying and complete defoliation
Talinum paniculatum	No feeding
Trianthema portulacastrum (horse purslane)	No feeding

Pesticides that are commonly used in areas inhabited by the purslane sawfly were screened for larval tolerance. Even at very low rates, the insecticides in the test completely killed the sawfly larvae (Table 2). When applied directly to the larvae and their food supply, herbicides were also lethal. However, when applied to the soil during the pupal stage, they did not cause death. Of the two fungicides tested, maneb was the only one that caused any mortality, and then it affected only a small percentage of the population.

These results indicate that extreme care must be taken in applying pesticides to avoid harming the purslane sawfly population.

A deadly microsporidian

The purslane sawfly is extremely susceptible to infection by a particular microsporidian, which is a type of parasitic organism. Spores of the microsporidian enter the host through its digestive tract as it feeds. The microsporidian can also be transmitted to progeny of an infected female via the egg.

Typically the purslane sawfly microsporidian infects the midgut, fat bodies, gonads, and eventually the muscle tissue. The cytoplasm of infected fat bodies is filled with spores which defract light, giving the larvae a whitish appearance instead of their normal green color.

By acting as a natural check on the sawfly population, the microsporidian can actually benefit the sawfly. Without any population controls, there would be a tremendous increase in the number of sawfly larvae by late July, with a consequent increase in demand for food. Soon the purslane plants would be stripped of their leaves and succeeding generations of the sawfly would starve to death.

Table 2. — Percent Mortality 48 Hours After Pesticide Applications to Larvae on Foliage

Pesticide	Rate of application		
	10% of normal	Normal	10 X normal
	Pct. destruction		
Insecticides			
Carbaryl	100	100	100
Malathion	100	100	100
Biological agent			
Bacillus thuringiensis	20	50	100
Herbicides			
DCPA	0	100	100
Nitrofen	0	100	100
Trifluralin	10	75	100
Fungicides			
Chlorothalonil	0	0	100
Maneb	0	10	95
Control			
Water	0	0	0

A useful weapon

Weed control by the use of insects has been most successful in range lands or other uncultivated areas. Since common purslane grows in intensively cultivated areas, it does not fit into the pattern of usual biological control. However, the purslane sawfly does have the potential of partially controlling purslane in cultivated areas and completely controlling it in areas that are not heavily cultivated and do not receive heavy pesticide applications. Once the sawfly has stripped the purslane of its leaves, regrowth is very slow, with the new leaves being continually fed upon.

If managed properly, the purslane sawfly can be a valuable weapon in the battle against purslane.

How Fescue Inhibits Growth of Sweetgum Trees

A. R. GILMORE

FORESTERS have generally assumed, on the basis of experience, that trees planted in association with fescue will not grow very fast. Another assumption is that the slow growth is due to competition between the fescue and trees for water.

An ongoing experiment at the Enfield Experimental Field in southern Illinois affirms the first of these assumptions. The height growth of 10-year-old sweetgum trees (*Liquidambar styracifula* L.) growing in plots containing fescue (*Festuca arundinacea* Shreb. var. Ky. 31) is less than that of trees in adjacent plots without fescue.

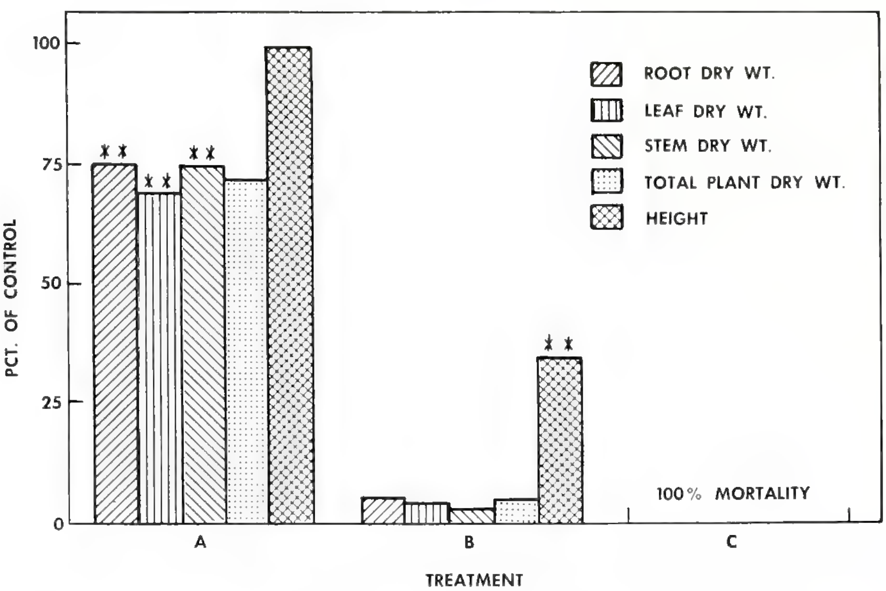
However, the second assumption — that the poor tree growth is due to competition for water — has not been borne out. In fact, measurements of topsoil moisture throughout the 1974 growing season consistently showed more moisture on the fescue plots than the nonfescue plots.

Results from chemical and physical soil analyses also failed to account for differences in height of seedlings grown in the fescue and nonfescue plots. While sweetgum growth was correlated with residual phosphorus and magnesium, this correlation was achieved across all experimental plots regardless of whether fescue was present. These results suggested that fescue caused an interference reaction on sweetgum over and above the response of sweetgum growth to environmental variation.

Interference is the deleterious effect that one plant may have on the growth of another through the combined action of competition and allelopathy. Competition occurs when one or more growth factors in a plant's environment are removed or reduced by another plant sharing the same habitat. Allelopathy is any direct or indirect harmful effect on one plant due to chemical compounds produced by another plant.

Any part of a plant may release chemicals that inhibit the growth of other plants. However, leaves and roots are the most consistent sources of inhibiting substances, since they contain large amounts of diverse plant metabolites. These substances may be leached from roots or aboveground plant parts, actively exuded from living roots as the result of environmental stimulus, or leached from decaying plant residues.

A. R. Gilmore is professor of forestry.



Interference effects of fescue on dry weight of sweetgum. Treatments are fescue seeded in association with sweetgum for 2 months (A) and 4 months (B), and sweetgum seeded into mature fescue (C). **Indicates significant difference from the control at the 99-percent confidence level. (Fig. 1)

Greenhouse experiments

Two greenhouse experiments were conducted to determine whether fescue does indeed cause an interference reaction on sweetgum trees. In the first experiment, 2-month-old seedlings were grown in pots containing quartz sand. There were four treatments. Three of the treatments consisted of seeding fescue (a) 2 months before the sweetgum was planted, (b) at the same time that sweetgum was planted, and (c) 2 months after the sweetgum planting. In the fourth, or control, treatment, sweetgum was grown without fescue.

This experiment was terminated after 4 months. Results showed that interference effects were present, but effects due to competition could not be separated from those due to allelopathy (Fig. 1).

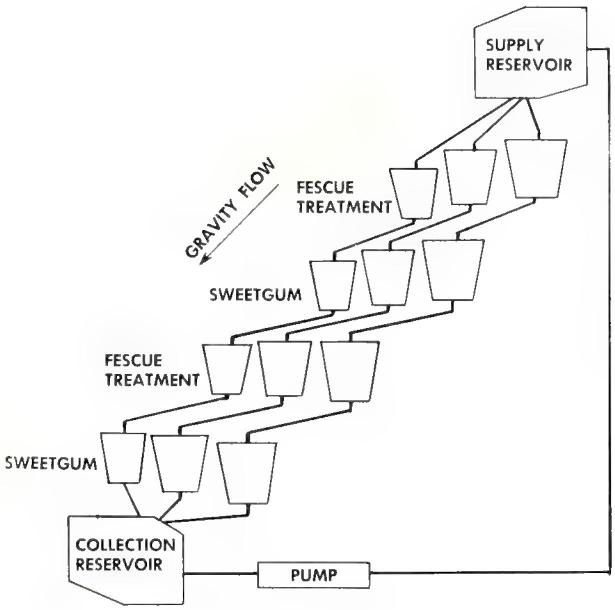
A second experiment was set up to eliminate the competitive aspect of interference and isolate the allelopathic effects. For this, a stairstep apparatus was constructed (Fig. 2). A nutrient solution from a supply reservoir was applied to pots on the uppermost step. The solution was allowed to filter through the quartz sand growing medium into the pots on the next step. After the solution had filtered through the entire system, it was pumped to the supply reservoir to begin the cycle again.

Each treatment line on the stairsteps consisted of three pots per step

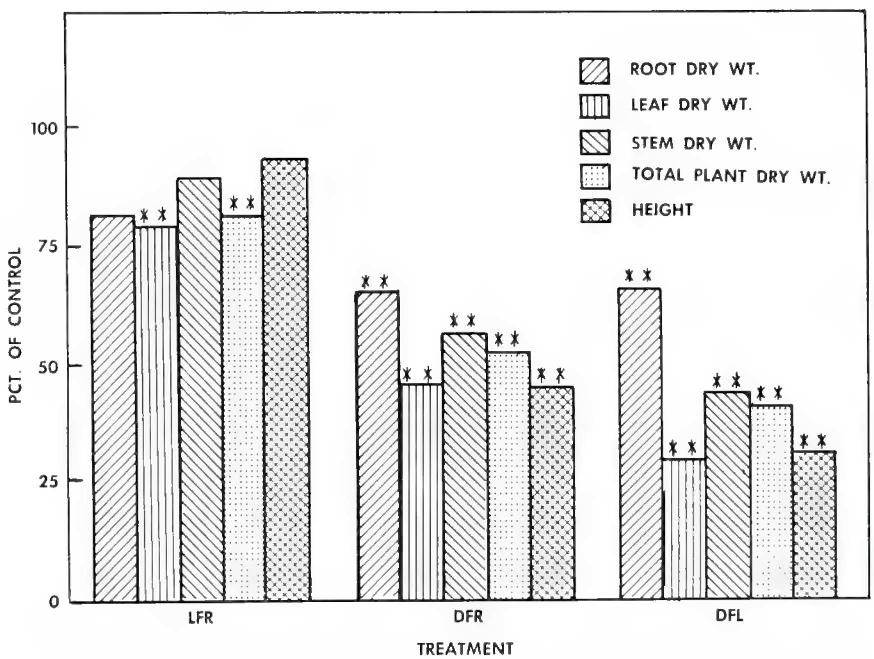
(Fig. 2). There were four treatment lines, including a control series. Pots in the test series contained alternating fescue treatments and sweetgum seedlings in quartz sand. The seedlings were planted three to a pot. In the control series, pots of seedlings were alternated with pots of quartz sand without fescue materials.

Fescue treatments consisted of leachates from (a) live mature fescue, (b) air-dried fescue leaves, and (c) air-dried fescue roots. Leaves and roots were cut up and incorporated into the sand of the pots at the rate of 30 grams of air-dry tissue per pot, which represented the amount contained in an area in the field with the same diameter as the pot.

At the end of 30 days, the seedlings were harvested and plant height and dry weight of leaves, stem, and roots were measured. Nitrogen, potassium, phosphorus, calcium, and magnesium were determined on the dried sweetgum leaf and root tissues.



Schematic diagram of one treatment line of the stairstep apparatus. (Fig. 2)



Allelopathic effects of fescue on dry weight of sweetgum. Treatments are 1-month-old sweetgum grown in contact with materials leached from live mature fescue roots (LFR), dead fescue roots (DFR), and dead fescue leaves (DFL). **Indicates significant difference from control at the 99-percent confidence level. (Fig. 3)

Allelopathy predominates

All seedlings grown in contact with fescue leachates were reduced in growth and in dry weight of various plant parts (Fig. 3). The most pronounced reductions were in the height and leaf dry weight of plants receiving leachates from dead fescue roots and leaves.

The leaves of seedlings treated with leachates from the dead fescue materials turned yellow 12 days after the start of the experiment. These seedlings contained one-third as much nitrogen per gram of plant top as the control. Phosphorus content of the leaves was also reduced. There were no clear-cut effects on potassium, calcium, and magnesium.

These results suggest that allelopathy accounts for most of the interference by fescue in sweetgum growth. Apparently the release of allelopathic substances is greatly increased when the fescue tissue is broken down and decomposed. This is indicated by the fact that leachates from the dead leaves and roots had the greatest effect on sweetgum growth.

The decrease in phosphorus concentration in the sweetgum tissue indicates a deficiency in the ability of fescue-treated seedlings to absorb phosphorus. This might be attributed to a decrease in mycorrhizae in the roots of these seedlings. Similar reductions in nitrogen concentrations suggest impaired absorptive capacity of the roots for nitrogen.

The yellow leaves on seedlings treated with dead fescue roots and leaves were possibly due to a deficiency of chlorophyll. Phosphorus and nitrogen deficiencies may have inhibited the ability of these seedlings to synthesize chlorophyll and subsequently increase their biomass.

Exploring a Biological Milk Factory

CRAIG R. BAUMRUCKER

MANY OF US think of the dairy cow as a milk factory. Actually, the cow's mammary gland, or udder, contains billions of miniature "factories." Each of these factories is an individual secretory cell with the total biological machinery for acquiring materials from the blood and converting them to milk components.

Under the microscope

With optical and then electron microscopy, the mammary tissue can be increasingly magnified to reveal its organization and constituent cells. Progressive enlargements of a section of the udder are shown in Figure 1. The first thing visible under a microscope is the duct system in which milk is stored until milking (Fig. 1A and B). Feeding into the duct system are numerous alveoli (Fig. 1B and C). Each alveolus contains many secretory cells in a single-layer configuration that somewhat resembles a hollow ball. These cells are arranged so that the blood supply via capillaries is at one surface and the lumen (place for milk release) is on the other.

Figure 1D is an enlargement of three lactating secretory cells. Their great complexity is clearly evident. Once the electron microscope revealed these numerous structures, investigators were prompted to find out more about them and their function in the production of milk.

Cell separation

To understand the function of the various cellular structures, it is necessary to isolate the individual components. The separated material from one cell would be virtually undetectable; however, pooling the components of many secretory cells yields enough material for study.

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Cell separation methods developed with the technological advance of the ultracentrifuge. This instrument is capable of speeds up to 80,000 revolutions per minute without increasing temperatures. (Excessive heat injures many biological functions.)

The spinning action of the centrifuge creates a force comparable to that of gravity, and the ultracentrifuge can routinely generate a force 200,000 times greater than gravity. This artificial gravitational pull can be used to force cellular components downward at rapid rates. However, in a uniform solution this will only move cell materials from the top of the centrifuge tube to the bottom without separation.

Objects float or sink in a solution by virtue of their densities or the density of the solution. An example is the greater ease with which a swimmer can float in ocean water than in fresh water. The high salt concentrations in marine water make it denser, giving greater buoyancy to the swimmer.

The application of this concept was the second advancement in cellular separation. Each cell part has a density (weight) similar to that of an analogous part from another cell, but different from all other cell parts. Thus, cell parts can be separated if centrifuged through solutions with different densities.

The solutions can be made by adding different amounts of a given ingredient to water. Usually sucrose (table sugar) is used. A prepared centrifuge tube for cell fractionation has several layers of solutions of different densities, with the most dense at the bottom (Fig. 1E). The density differences of the solutions produces sharp boundaries (interfaces) where the solutions come in contact.

Experimentally, cell separation occurs as follows: (1) The mammary tissue is homogenized, breaking open intact cells and releasing cellular components. (2) Homogenized material is put upon the top of the centrifuge tube (total cell material, Fig. 1E). (3) The tube is centrifuged at high rpm for various times.

During centrifugation the cellular components are forced down through solutions of increasing densities under the greatly exaggerated force of gravity. However, when a cell part meets a solution of greater density than itself, it floats at that interface rather than continue to sink. No matter what the force of gravity, the cell part will continue to float because it is buoyed up like a swimmer in ocean water.

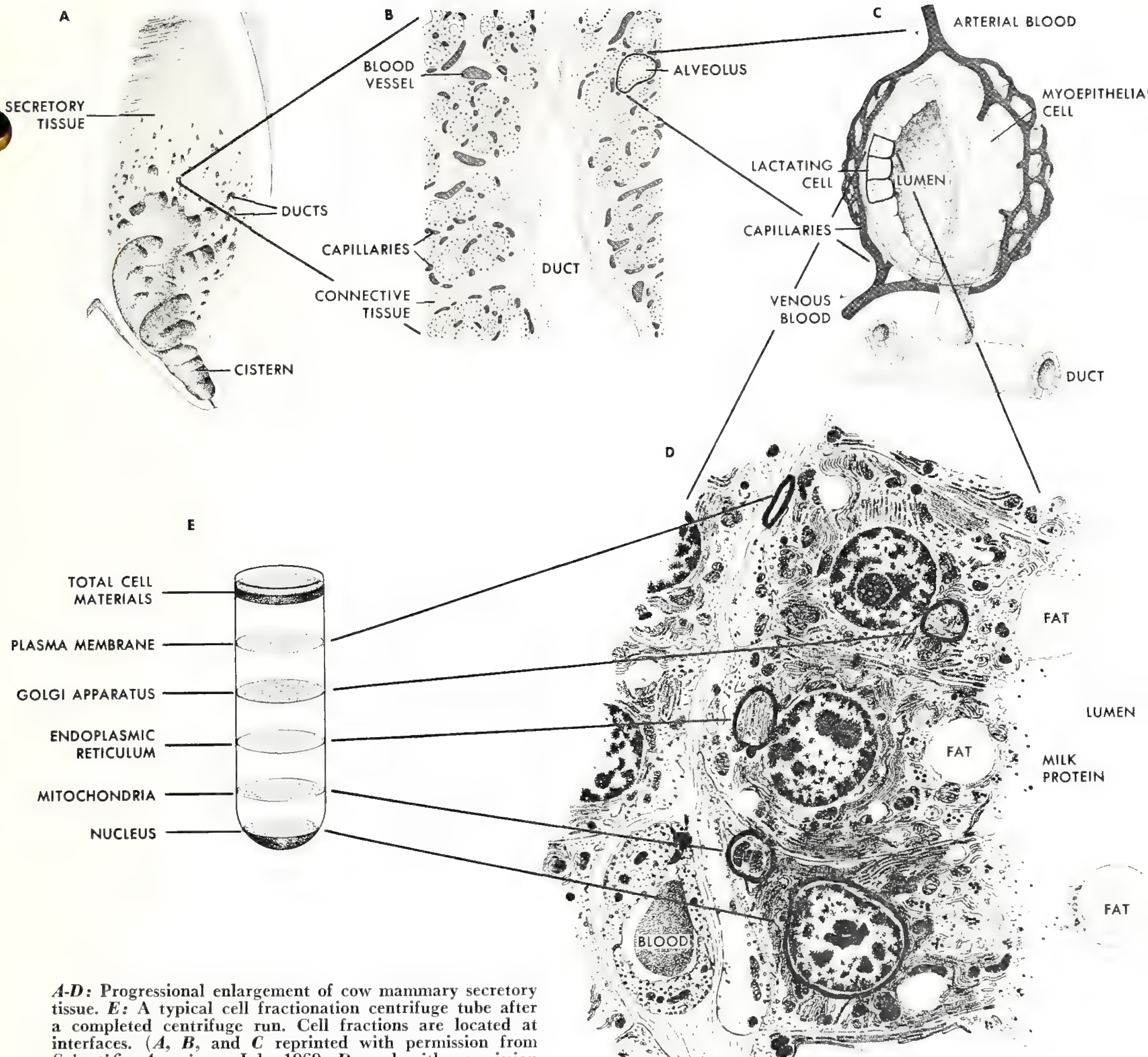
Nuclei of the cells, the densest particles, will pass through all gradients and will form a pellet at the bottom of the centrifuge tube. Mitochondria will penetrate all but the last gradient solution. Similarly, each cellular component will find a level beyond which it cannot penetrate and will come to rest at a specific interface. (These density levels are not arbitrary, but have been selected after extensive studies.)

Thus, what started as a mixture of mammary cell parts becomes separated by their different densities, each fraction collecting at the interface of the solution that is denser than the particular component. Interface fractions are then individually collected and used in experimental studies.

Such studies have ascribed various biological processes involved in milk synthesis to specific mammary cell components. Some of these are:

Nucleus. Site of genetic material which regulates the manufacture of specific milk products (for example, lactose and casein).

Mitochondria. Site of energy production, the energy being used in



A-D: **Progressional enlargement of cow mammary secretory tissue. *E:* A typical cell fractionation centrifuge tube after a completed centrifuge run. Cell fractions are located at interfaces. (*A, B,* and *C* reprinted with permission from *Scientific American,* July 1969. *D* used with permission of C. Heald and D. Saacke.) (Fig. 1)**

synthesis and transport of milk constituents. Also site where various blood materials are partially converted into milk constituents.

Endoplasmic reticulum. Site of milk protein (caseins) manufacture and of all enzymes that manufacture milk.

Golgi apparatus. Site of lactose (milk sugar) manufacture.

Plasma membrane. Site where raw materials enter lactating cell (blood side) and manufactured milk components are released (lumen side). It also forms the coat around each milk fat globule (*see* "fat," Fig. 1D) released into milk.

Knowledge is basic

Each process in milk production is extremely diverse and complicated. However, by applying the concept of "divide and conquer" to lactating mammary secretory cells, we are working toward a better understanding of how milk is made. The application of such knowledge is beyond any speculation at this point, but certainly we need to understand the process before further improvements can be made in the lactation performance of the dairy cow.

Estrogenic Compounds in Foods

S. T. WOLFORD, C. J. ARGOUDELIS, J. TOBIAS, and J. M. BAHR

Every day, we unknowingly consume small quantities of biologically active substances in our food. Some of these, such as enzymes and protein hormones, are probably destroyed by digestion. Others, including vitamins and minerals, can be absorbed and later cause beneficial reactions in body tissues. A third group includes substances whose roles in the body are yet unknown. This group includes many food additives that are now being intensively investigated.

We are particularly interested in estrogens, those hormones responsible for reproductive cycles in females. We would like to know what quantities of estrogens are ingested by the average person and what, if any, effects it may have. Estimates of dietary intake of estrogens have ranged from 30 μg. daily for a person on a low-fat diet to 2 mg. daily for someone on a diet very high in fat.

When dealing with hormones in foods, it is necessary to distinguish between those that occur naturally and those that are residues of synthetic compounds (for example, the estrogens in meat or milk from animals fed estrogen supplements). The dietary residues are not permitted in foods, so their presence is carefully monitored. The effects of naturally occurring hormones pose more basic questions; the answers could determine whether we should continue to eat some of our present foods.

Early studies

Estrogen research is not new. As far back as 1929, one group of scientists reported estrogenic activity in cows' milk. The amount of activity depended on the physiological state of the cows, their feed, and the soil of their pasture land.

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The amounts of estrogens in foods are so minute that they have to be measured in micrograms, nanograms, or even picograms. The following will give an idea of what these measurements mean:

1 gram (gm.) = 0.035 ounce
1 milligram (mg.) = 0.001 gm.
1 microgram (μg.) = 0.000001 gm.
1 nanogram (ng.) = 0.000000001 gm.
1 picogram (pg.) = 0.000000000001 gm.

Later, another group reported estrogenic activity in several kinds of vegetable oils and animal fats. They found that olive oil or corn oil could reverse menopause symptoms in some women. They estimated that the body could absorb more estrogens from a high-fat diet than are present in normal women. Estrogens also have been reported in eggs, shellfish, kidneys, and snails. Two other groups found estrogenic activity in soybeans and their products.

There are many reports of estrogenic activity in animal feeds. Its presence in certain clovers has been shown to decrease ewe fertility and increase lamb mortality. Other legumes, wheat, carrots, and rye also have estrogenic activity. Sterility among women in Holland has been attributed to their ingestion of tulip bulbs with estrogenic activity at the end of World War II.

It is generally recognized that the activity found in plants is not caused by the "classical" estrogens — those found in animals. Many of the plant compounds have been characterized as *iso*flavones or coumarins. The estrogen contents that various investigators have found in some common plant and animal products are given in Table 1. The variety of foods listed and the greatly variable amounts for a given food indicate why it is so difficult to estimate an average estrogen intake.

Milk is emphasized

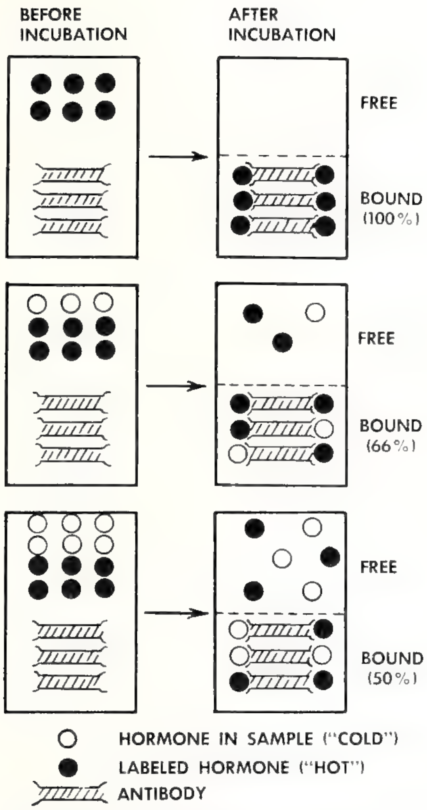
Milk and its products have been the foods most widely investigated for estrogen content. Since infants and young children consume large quantities of milk, we want to assure ourselves that no deleterious effects are occurring during these developing years. On the other hand, since nature designed milk for the very young, perhaps it is detrimental to adults! Some claims have implicated dairy products in breast cancer, premature menarche, acne, and even feminization of male athletes. While many people feel these claims are unjustified, scientists bear the burden of proving or disproving them.

During the 1950's and 1960's, several investigators attempted to measure the estrogens in milk. The two main methods used were the measurement of uterine weight increase in young or ovariectomized mice, and the Allen-Doisy test, which measures

Table 1. — Estrogens (or Substances Like Estrogen) in Common Fats and Plants, as Reported by Various Investigators

Substance tested	Estrogen, mg./100 gm.[a]
Animal fats	
Pork	0.3; 1.2-1.4; 21
Beef	1.0; 8-40
Butter	0.8; 2-2.6; 28
Vegetable products	
Olive oil	0.25-5.2; 5-35
Soybean oil	0.8; 10
Palm oil	0.9; 14
Peanut oil	0.25; 10
Cocoa butter	0.8; 3
Corn oil	0.1; 1.5; 87
Clover	0.22-0.32
Carrots	3.6; 10.5
Wheat	4.8; 58.5

[a] More than one range or amount for a given substance indicates the results obtained by different investigators.



Schematic representation of radioimmunoassay. The ratio of hot to cold hormones in the bound fraction indicates ratio in the free fraction. (Fig. 1)

the degree of vaginal cornification in mice. Neither test is very reliable. The uterine weight response is not specific for estrogens; it can be induced by progesterone, androsterone, testosterone, and dehydro*iso*androsterone. The Allen-Doisy test is more specific but is particularly subject to experimental error. Using these tests, some researchers found significant amounts of estrogen; others did not.

It is now believed that milk contains estrogens in amounts too small to be detected by these means. Colorimetric tests can measure as little as 10 ng., but require very pure samples. Reported values range from 12 ng./ml. to 40 μg./ml. in milk from nonpregnant cows. This great variation emphasizes the inadequacy of the techniques used. However, these determinations did enable us to discover that the amount of estrogen in milk increases during pregnancy and under some abnormal conditions.

Later, researchers used such techniques as gas-liquid chromatography and thin-layer chromatography to identify other steroids in milk, but estradiol (the major natural estrogen) and related compounds did not show up.

About 1970, two rapid and very sensitive techniques were developed: the competitive protein binding assay, and the radioimmunoassay (RIA). The latter was immediately applied to the determination of progesterone in milk, which developed into a pregnancy-detection method. This method is being improved by research at the University of Illinois and elsewhere.

How RIA works

The great advantages of the RIA are its sensitivity and specificity. It is now routinely performed in hospitals to quantitate blood hormones.

RIA is based on the immunological properties of the hormone being studied — estradiol or estrone in our current work. First, to obtain specific antibodies, an animal is injected with a hormone-protein conjugate, because small molecules such as steroid hormones cannot stimulate antibody production by themselves.

After several months, the animal is bled, and the serum fraction that contains the antibodies is isolated. The antibodies' ability to recognize and combine with free steroid molecules forms the basis for the test.

To perform the assay, a sample with an unknown quantity of hormone is incubated with a small known quantity of the antibody and a certain quantity of radioactively labeled hormone. As illustrated in Figure 1, the radioactive or "hot" hormone competes with the "cold" hormone for the limited number of hormone-binding sites on the antibodies.

The ratio of hot to cold in the antibody-bound fraction equals the ratio of hot to cold in the free fraction. These two fractions are separated by one of several techniques. Radioactivity in the bound fraction is detected with a scintillation counter. The lower the radioactivity count, the greater the amount of hot hormone that has been displaced from the antibody by the cold hormone. The percentages of radioactivity in the antibody-bound fractions are plotted versus the log of pg. of hormone in standard solutions. From this curve, we can calculate the amount of estrogen in an unknown sample, once radioactivity in the bound fraction has been determined.

Current studies of milk

We plan to use the RIA to measure the amounts of estrogens in consumer dairy products. So far, we have examined unprocessed pooled milk from the University herds.

One difficulty associated with milk, but not with other fluids such as blood and urine, is its high fat content. The organic solvents used to extract the estrogens also extract the fat, which interferes with the assay. We have worked on three different ways to eliminate fat and other substances: (1) Extraction with an alkaline solution. (2) Column chromatography using silicic acid. (3) Precipitation of the fat in 70 percent methanol.

By utilizing the last method, scientists in another laboratory recently used the RIA to follow changes that occur in estrogen content of milk with the reproductive cycle. Their data are given in Table 2 along with some we have recently obtained. It can be seen that these values are only about one one-thousandth as great as those previously obtained by other methods.

We hope to extend this work to determine the distribution of estrogens in other products. These newer methods should help chart an area that is still relatively unexplored.

Table 2. — Estrogens in Milk, RIA Method[a]

Stage of pregnancy	Estrone	Estradiol	Sum
		pg./ml.	
55-81 days	57	85	142
107-145	35	52	87
205-209	97	49	146
Nonpregnant	43	37	80
Pooled milk, U. of Ill.	16-47	12-130	

[a] First four lines of data supplied by E. L. Monk, R. E. Erb, and T. A. Mollett of Purdue University (J. Dairy Sc. 58:34, 1975).

Working and Nonworking Wives' Expectations as to Future Employment

JANET HUNTER-HOLMES and JEANNE L. HAFSTROM

Within the past 25 years, the proportion of wives working outside the home has nearly doubled. Today almost one-half of all women with employed husbands are engaged in some form of gainful employment.

Much has been written about the possible consequences of a wife's employment — for example, its effect on the personal and social relationships of a married couple and on the way in which a woman perceives herself and her role. A further concern has been the possible way in which a mother's employment may affect her child-rearing practices.

Will the proportion of wives and mothers in the labor force continue to increase? What factors are related to a working wife's intentions to continue working outside the home? If a woman is not working outside the home but expects to do so in the future, what factors are related to this expectation? To study these questions, research was recently undertaken in the area of Family and Consumption Economics.

Available data

Data were available from the 1970-71 Survey of Life Styles of Families conducted by family and consumption economists at the University of Illinois. This survey excluded student households and included only families in which the mother was less than 65 years of age and at least one child under 18 years was living at home.

For the present study, we selected 405 households from the sample of "typical" families that had been stratified by the occupation of the household head and randomly selected. We included only households that consisted of a mother, father, and at least one child. Thus, only nuclear families are included, and all wives discussed are also mothers.

Janet Hunter-Holmes is visiting assistant professor and Jeanne L. Hafstrom is associate professor of family and consumption economics.

Four groups

As part of the original survey, women were asked whether they were currently working outside the home for money. They were also asked if they expected to be working outside the home in five years. For our study, we classified the 405 women into four groups on the basis of their responses to these questions:

Group I (29 percent of the sample). Wives who were not working and did not expect to be working in five years' time.

Group II (22 percent). Wives who were not working but expected to be doing so in five years.

Group III (10 percent). Wives who were working but did not expect to be working in five years.

Group IV (39 percent). Wives who were working and expected to be doing so in five years.

Certain socioeconomic and social-psychological variables were selected from the original questionnaire. These variables were analyzed to determine whether significant differences existed among the four groups of women. Statistical analysis of the data was done using the chi-square test. The groups were found to differ significantly for these 17 variables:

Socioeconomic

- Education of woman
- Educational difference between husband and wife
- Age of woman
- Age of husband
- Age of youngest child
- Length of marriage
- Time in present house
- Wife's type of employment
- Family income
- Money problems

Social-psychological

- Satisfaction with level of living
- Satisfaction with time spent with husband
- Satisfaction with marriage
- Husband's attitude toward wife working
- Who decides wife should work
- Reason wife works
- Reason wife expects to work

In the following characterizations of the four groups, variables are discussed only when the actual frequency within a group differs from the expected frequency.

Group I characteristics

Women who were not working and did not expect to be working in five years were more likely than the other women to have had some college education without having received a degree. Their youngest child was 3 years old or younger, and their family income before taxes was $15,000 or higher. These women were more likely than the other groups to indicate that they never had money problems. Women in this group tended to be satisfied with several aspects of their lives. In fact, they were very satisfied with their levels of living. They were also very satisfied with the time spent talking with their husbands and with their marriages in general.

Most of them perceived that their husbands were opposed to women working outside the home. They also were inclined to feel that whether

they did work or not was mainly their husbands' decision.

Group II characteristics

The women who were not working but expected to do so tended to be 30-34 years old and have a husband in the same age group. Their youngest child was likely to be 4 or 5 years old. These women tended to have college degrees and husbands who had more education than they had. They tended to have been married five years or less and to have lived in their present home for one year or less.

These wives sometimes had money problems. They were only somewhat satisfied with the amount of time spent talking with their husbands and tended to be more dissatisfied with their marriages than the other groups. They perceived that their husbands' attitudes toward wives' working was a qualified yes — which was related to a feeling that it is all right for a mother to work when the children are older.

The need for an outside interest as a reason for expecting to work was more likely to be cited by this group than by the women who were already working and planned to continue doing so.

Group III characteristics

The working wives who did not expect to be working in five years tended to be older than the others — 45 years or older — and to have husbands aged 50 or more. As would be expected then, they tended to have been married 26 years or longer, and their youngest child was more likely to be at least 12 years old than in the other groups. These women were more likely to have lived in their present home 10 years or more. Their educational level tended to be four years of high school or less.

Family income before taxes was in the $7,000-$10,000 range. These women often had money problems. They were somewhat satisfied with their marriages.

Compared to the women who were working and expected to continue, Group III women were more likely to have blue-collar or clerical-sales types of jobs. They were also more likely to give the need for another interest as a reason for working.

Group IV characteristics

Women who were currently working and expected to be doing so in five years were more likely than the other groups to be in the 35-39 age bracket, and their youngest child was more likely to be 6 through 11 years old. These women were also more likely to have had 17 or more years of education. However, they tended to have husbands with less education than they had or with the same amount that they had.

The family was more likely than families in the other groups to have lived in their present home at least five years but less than ten. And family incomes were more likely to be in the $10,000 to $15,000 range. The women tended to be somewhat satisfied with their levels of living.

In comparison to the other women, the women in this group were more likely to feel that the husband and wife together decided whether the wife should work outside the home. As might be expected, they perceived that their husbands preferred or approved of a working wife.

Compared to the women who were working but expected to stop, Group IV women were more likely to have professional, technical, or managerial jobs and to be working because they enjoyed it. Compared to the women who were not working but expected to do so in five years, the women in Group IV were more likely to say that they expected to be working in five years because they needed the money.

Some implications

Although slightly less than half of the 405 wives in this study were working at the time of the interviews, over three-fifths of them expected to be working outside the home in five years. From the findings presented here, it would appear that women who expect to be working have certain characteristics in common: They are more likely to be in their thirties and their youngest children tend to be 4 through 11 years old. Many of the women have college educations, and most of them have husbands who favor their working. Wives who do not expect to be working in five years have these characteristics in common: they tend to have less than a college degree and are satisfied with their marriages.

If a goal of society is to increase the number of women in the labor force, then more programs to encourage college or higher education for women might be developed. Also, it appears important to initiate programs that would encourage men to have positive attitudes toward wives working outside the home.

Since the youngest children of women who expect to be working are generally 4 to 11 years of age, some changes may need to be made in the type of child-care facilities. These facilities may need to be oriented more to the care of children before and after school hours than to the day care of preschoolers. This type of child care might encourage more mothers to work.

The information presented here may have additional implications for adult education programs. People planning extension and other adult programs may need to be more flexible in their times of presentation, offering programs for working wives in the early morning and noon hours as well as evenings. Also, more television and radio programs may need to be presented at times when working wives may see or hear them.

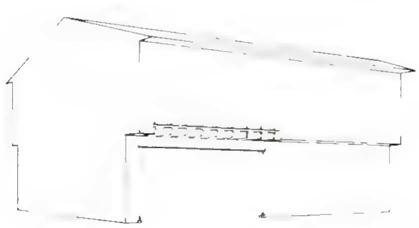
It would appear from our findings that programs for working wives should be designed to appeal to women 30 to 45 years of age whose youngest children are 4 to 15 years old, and who have relatively high levels of education. Other extension education programs might continue to be designed for homemakers 45 years of age and older, as well as for mothers with very young children. Most of the women who are not working are likely to be in these groups and available for meetings at the traditional times.

Particleboard Tested for Door Headers

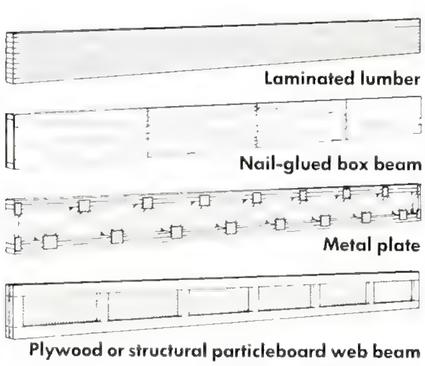
D. H. PERCIVAL

WOOD has been used for centuries to build houses, so most of us never give lumber a second thought. However, the decreasing supply of large, high-quality logs, needed for the larger sizes of construction lumber, is creating a problem. For example, the 2 x 14's that have been used for clear-spanning long distances, such as headers for two-car garage doors (Fig. 1), generally are no longer available. A special order is usually necessary for 2 x 12's, and it is becoming harder to find 2 x 10's in the high structural grades.

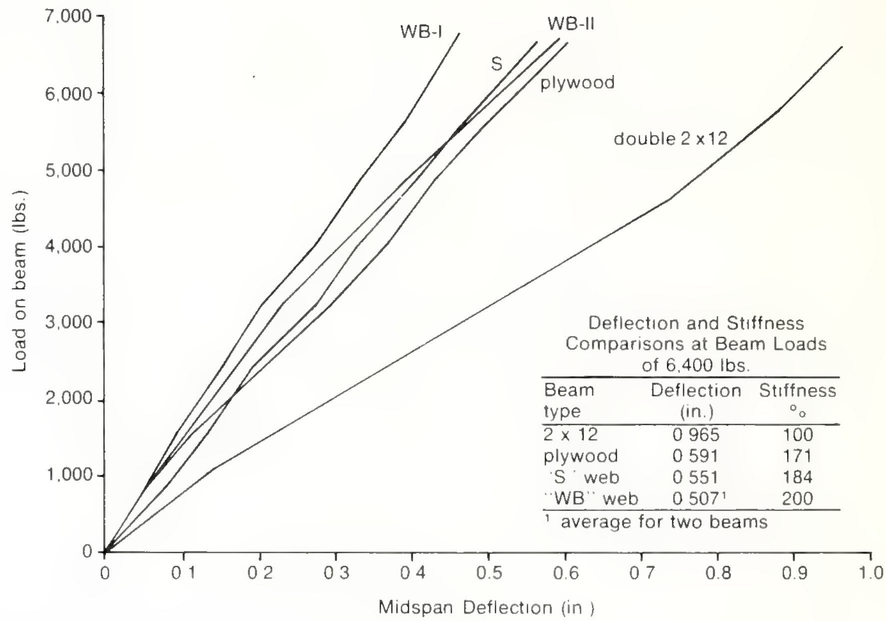
As a result, effort is being made to develop engineered components utilizing smaller sizes of lumber. Although these smaller sizes require special grading to assure adequate stiffness and strength, they can be used for light-frame or house construction that meet building code requirements and even provide superior performance. For example, roof trusses have replaced conventional joist-rafter construction in many areas of the country; factory-built wall panels are replacing "stick-built" wall framing; and parallel-chord floor trusses are being used in place of solid lumber floor joists.



Header for a two-car garage supports floor, wall, and roof loads. (Fig. 1)



Four types of garage-door beams. (Fig. 2)



Load-deflection curves for 16-foot garage header. **(Fig. 3)**

Using smaller structural grades of lumber and some of the new particleboard panels entering the market, the Small Homes Council and Purdue University's Wood Research Laboratory have cooperated in designing and testing 16-foot, clear-span door headers for two-car garages.

Four engineered headers are shown in Figure 2. One was made of particleboard and structurally graded 2 x 4 lumber. Particleboard is manufactured from small wood chips, flakes, and sawmill or paper mill residues that have been mixed with glue and hot-pressed into sheets or panels.

Figure 3 shows the load deflection test results for four types of experimental headers in comparison with a conventional header made of double 2 x 12 lumber. The 2 x 12 header had more deflection from the test loads than any of the engineered headers.

The experimental headers are shown on the graph as WB I, WB II, S, and plywood. WB I and WB II were fabricated of stress-rated 2 x 4 lumber and sliced hardwood flakeboard. The S beam combined stress-rated 2 x 4 lumber with particleboard made of residues from the furniture industry. The plywood beam was similar but was made of ½-inch structural plywood. All headers were nail-glued. In addition, a header fabricated with metal-toothed truss plates was tested and was also stiffer than the double 2 x 12 header.

Even though all these engineered headers performed better than the double 2 x 12 header, we are not suggesting that the particleboard beam design be used until the tests are replicated. It is hoped that this pilot study will arouse enough interest that further research will receive financial support.

D. H. Percival is research professor of wood technology and utilization, Small Homes Council–Building Research Council.

Properly planned, this borrow pit pond could have been more attractive and better adapted to recreational uses.

Planning Enhances Value Of Borrow Pit Ponds

ROBERT D. ESPESETH

TRAVELING the Interstate highways and other major roadways of Illinois, one can see hundreds, perhaps thousands, of borrow pit ponds that have been created in the process of road construction.

In Champaign County alone, there are 138 borrow pit and other small ponds, according to a recent inventory by the Champaign County Regional Planning Commission. These ponds provide 378 surface acres of water. This may not seem like much, but to a county that has no natural lakes, few artificial lakes, and only portions of three major rivers, 378 acres of water is important. Essentially the same situation exists in most other counties of central Illinois — they are water-starved.

The 138 ponds in Champaign County, like those in the rest of the state, are being put to a variety of uses: fishing, swimming, camping, boating, home sites — and general dumping. However, with a bit more foresight and planning, most ponds could be providing a lot more recreation and aesthetic pleasure.

All too often borrow pits have been dug with consideration given only to the minimum cost to the contractor for removing a maximum of material. The landowner should consider the long-range potential of the pond and incorporate his desires into a contract with the excavator so that a usable site is the end product. Sometimes all that is necessary is a slight modification in excavation methods.

Robert D. Espeseth is outdoor recreation specialist, Office of Recreation and Park Resources.

Livingston County ordinance

How to make the most of borrow pit ponds has been demonstrated by the Livingston County Regional Planning Commission. Prompted by the impending construction of Interstate 55 diagonally through the county, they developed an ordinance and guidelines for borrow pit excavation. In this, they were assisted by the Office of Recreation and Park Resources, University of Illinois, and the Illinois Department of Conservation.

The Livingston County ordinance is the most comprehensive one for borrow pit excavations in the state. These are its basic requirements:

1. A registered engineer shall prepare a topographic map showing the existing and proposed conditions of the entire site. The Regional Planning Commission (RPC) will provide information on the design of the area, including shoreline configuration, plantings, above- and below-water slopes, and bottom configuration. Slope requirements follow those of the Department of Transportation (DOT) except that the above-water shoreline may not have more than a 6:1 slope for safety and prevention of excess erosion.

2. The DOT and the RPC shall have authority to review and approve design sketches before final plans are prepared.

3. Three copies of the final map and application shall be submitted to the RPC at least 21 days before the case is to be heard by the Board of Appeals. The RPC will give the map and application a final review and submit a recommendation to the Board. The Board will act on the application at a public hearing.

4. After the borrow site has been excavated, the contractor shall grade the site, redistribute stockpiled topsoil, seed turf areas, and plant trees and shrubs shown on the approved plan. The resident engineer of DOT shall inspect the completed borrow site to insure that the approved plan was followed. A final inspection will be conducted by the zoning administrator.

5. A performance bond shall be posted with the county in an amount sufficient to develop the borrow site in accordance with the approved plan if the contractor defaults. The amount and period of time for the bond will be determined by the Board.

A map showing possible pond configurations, slopes, and kind and location of plantings was developed as a guide for contractors. (A copy is available from the Office of Recreation and Park Resources, University of Illinois at Urbana-Champaign.) The final plans can be modified in various ways, but must go through the review and approval process specified in the ordinance.

In developing its program Livingston County has taken advantage of services available from the Department of Conservation: advice from the district forester, game biologist, and fish biologist on sources of trees, shrubs, and fish for a particular area; booklets on development and management of small ponds; and advice on developing specific sites.

Other applications

The Livingston County approach can not only be used by other counties, but can also be adopted for planning areas from which sand, gravel, or coal is to be removed. The important thing to keep in mind is the ultimate benefit to the owner and the community.

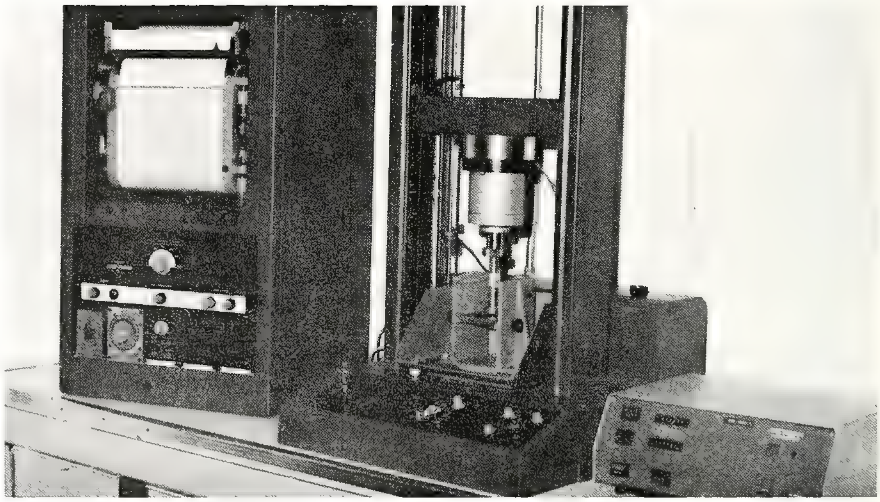
Soybeans' Susceptibility to Damage During Normal Handling Conditions

MARVIN R. PAULSEN

IF U.S. SOYBEANS are to continue their competitive position in world markets, maximum quality must be maintained. But how does one measure quality or assess damage? This is a major problem that has not been completely solved.

U.S. grading standards include guidelines for measuring some aspects of quality, such as test weight, moisture content, percent splits, percent foreign material, and percent damaged kernels. But they do not cover susceptibility to breakage during handling.

Soybeans may be handled 15 or more times before they reach a domestic end-user or crushing plant, and 25 or more times before they reach a foreign buyer's end-use plant. Each handling typically involves some type of mechanical moving, lifting, and dropping, with the ultimate impact of soybeans against hard metal or concrete surfaces or on other soybeans. Always the soybeans are placed under compressive loads or are moved at some speed before being impacted against other objects. The question then arises: How susceptible are soybeans to damage under such handling conditions?



Instron testing machine, 100-kilogram compression load cell, and integrator, used to measure the force and energy that a soybean can withstand. (Fig. 1)

Test procedures

Tests were conducted to measure the force required to cause soybean rupture, soybean deformation, and the energy absorbed by the soybean at rupture. It was assumed that once the seedcoat was ruptured or cracked, the soybean was damaged. Soybeans with cracked seedcoats split easily, becoming more susceptible to the invasion of fungi, which in turn reduces the soybeans' storage life. Cracked seedcoats also contribute to increases in fatty acids, which indicate a decline in oil quality.

To measure the force and energy that a soybean can withstand without cracking its seedcoat, an Instron testing machine equipped with a 100-kilogram compression load cell and an integrator was used (Fig. 1). Individual soybeans were deformed at 1 millimeter per minute between two parallel plates (Fig. 2). The effect of soybean position was studied by loading the soybeans in either the horizontal hilum position with the cotyledon interface in the horizontal plane or in the vertical hilum position with the cotyledon interface in the vertical plane and the hilum down.

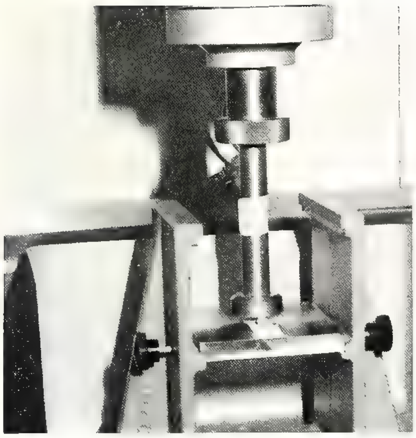
Three varieties — Amsoy-71, Corsoy, and Williams — were hygroscopically conditioned to moisture contents of 8, 11, 14, and 17 percent wet basis. Twenty soybeans of each variety were tested at each moisture and in each position.

Measurement results

The force required to rupture the seedcoat decreased as moisture increased from 8 to 17 percent (Fig. 3). When loaded in the horizontal hilum position, Amsoy-71 soybeans with 8 percent moisture required a force of 144 newtons (32.1 pounds) to rupture the seedcoat. With a 17-percent moisture content, seedcoats ruptured at a force of only 38.2 newtons (8.5 pounds). At all moisture contents, soybean seedcoats in the vertical hilum position ruptured with much less force — 58.4 newtons (13 pounds) at 8-percent moisture and 24.5 newtons (5.5 pounds) at 17-percent moisture.

The Williams and Corsoy varieties behaved much like the Amsoy-71 variety.

Marvin R. Paulsen is research associate in agricultural engineering.



Individual soybeans are loaded between two parallel plates. (Fig. 2)

Deformation at seedcoat rupture for Amsoy-71 soybeans loaded in the horizontal position increased from 0.85 millimeter at 8-percent moisture to 1.63 millimeters at 17-percent moisture. Soybeans loaded in the vertical hilum position also had increased deformation as moisture increased, but values were somewhat lower than those observed for the horizontal hilum position.

Energy absorbed by the soybeans at seedcoat rupture was measured and divided by the individual soybean volume. Thus, the effect of variations in soybean size could be reduced. Soybean volume was calculated from micrometer measurements of individual soybean length and diameters. An ellipsoidal shape was assumed. Typically individual soybeans ranged from 120 to 160 cubic millimeters in volume.

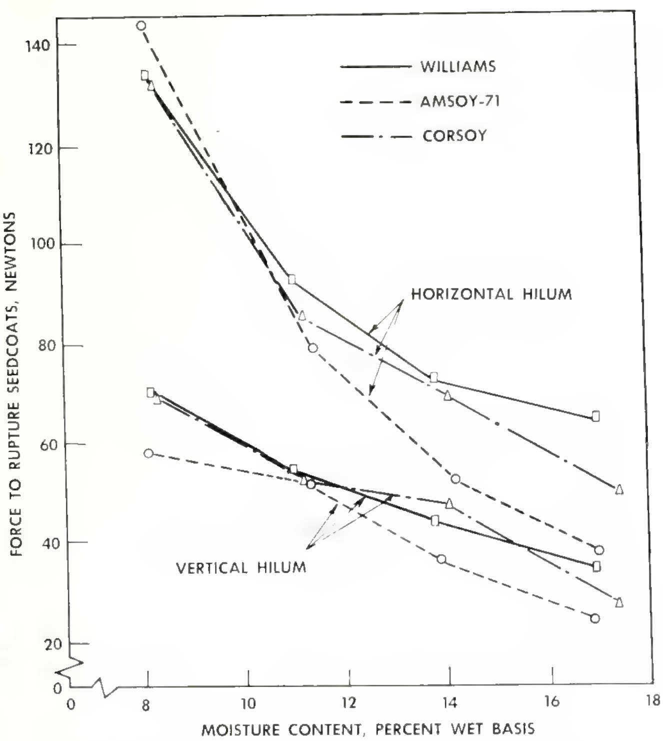
The quantity described as energy absorbed per unit of soybean volume was defined as toughness in millijoules per cubic millimeter. Generally, maximum toughness was obtained at the 11- to 14-percent moisture levels (Fig. 4). This would suggest that soybeans between 11 and 14 percent in moisture content are least susceptible to damage from compressive forces.

In another study involving compressive loading and impact, researchers found that it took about twice as much impact energy as compressive energy to bruise apples. This suggests that soybeans could withstand energy levels higher than those shown in Figure 4 if the force were applied for a very short time as in impact situations.

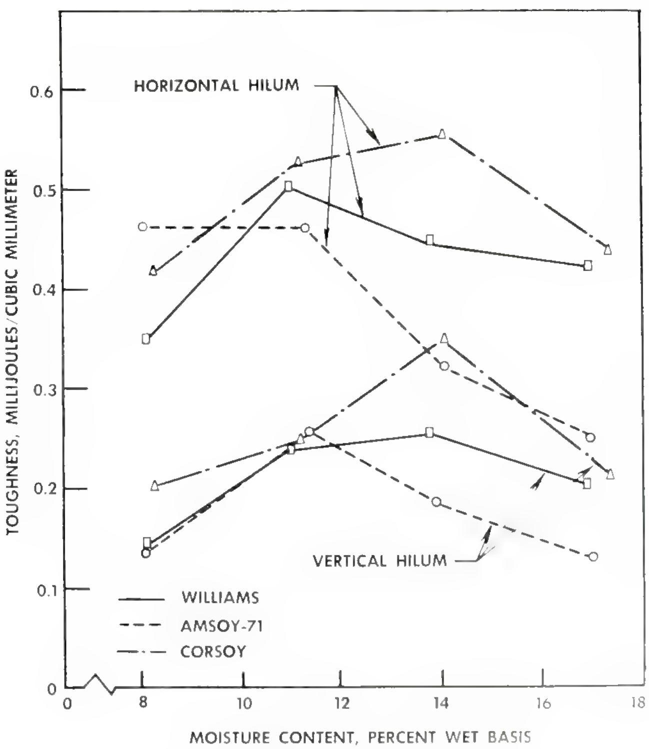
For comparison purposes, in a single fall of 31 meters (100 feet), a velocity of 19 meters (60 feet) per second would be reached, and 0.22 millijoule of energy would theoretically be exerted on 1 cubic millimeter of soybean volume.

As shown in Figure 4, all soybeans in the horizontal hilum position and many in the vertical hilum position can withstand more than this amount of compressive energy. However, since soybean orientation during handling can not be controlled, a certain amount of seedcoat rupturing and breakage would be expected. In previous studies involving drops of 31 meters, soybean breakage ranged from 2.2 to 5.6 percent, depending on soybean moisture and temperature.

The information obtained in this study will ultimately be used to help design materials handling systems with reduced soybean damage.



Force needed to cause seedcoat rupture as a function of moisture content for soybeans deformed at 1 millimeter per minute. (Fig. 3)



Toughness (energy per unit of volume) at seedcoat rupture as a function of moisture content for soybeans deformed at 1 millimeter per minute. (Fig. 4)

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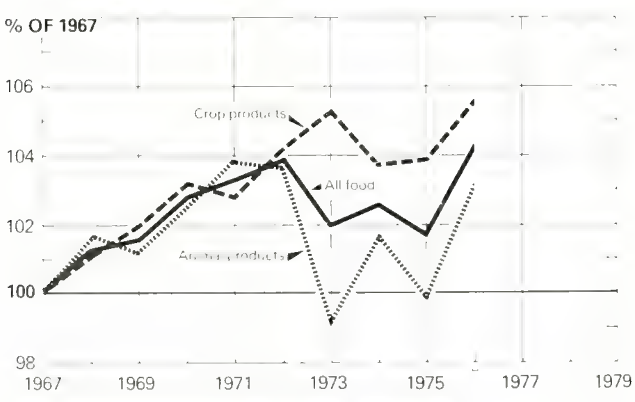
FARM BUSINESS TRENDS

PER CAPITA food consumption reached a new high for recent years in 1976, largely because of the increased output of the nation's farms and ranches. Various factors accounted for the high output, including increased crop production, continued liquidation of cattle herds, and a more favorable ratio of feed prices to animal products.

Typically, aggregate per capita food consumption varies relatively little from year to year — less than 2 percent. But consumption in 1976 was 3 percent higher than in 1975 and was 1 percent above that of 1972, the previous high of the past decade (Fig. 1).

In 1967, the base year for the chart, food consumption per person was estimated at 1,424 pounds (retail weight). This consisted of 632 pounds of animal products and 792 pounds of crop products. Typically consumption of animal products is slightly over 600 pounds, while crop products account for slightly over 800 pounds. The record high consumption since the U.S. Department of Agriculture started making these estimates in 1909 was 1,651 pounds, reached in 1945.

PER CAPITA FOOD CONSUMPTION



Changes in U.S. food consumption since 1967. (Fig. 1)

While total per capita food consumption is rather stable from year to year, there are sizable variations in individual items, largely due to available supply. Much of the increase in 1976 came from large supplies of meat. Broiler supplies were up 10 percent; beef was up 7 percent; and pork, 6 percent. Meat supplies will continue to be large this year. Per capita consumption of food may again be up slightly in 1977. By 1978 livestock production will likely adjust down and result in a slight reduction in per capita supplies.

Year-to-year changes in supply account for most of the yearly changes in per capita consumption. If a product is in large supply, it must be sold even though the price is less than the cost of production. The beef industry has been an example of this recently. Per capita consumption of beef has reached record levels but cattlemen have suffered substantial losses.

Over time, the changes in consumption of various food items largely represent changes in consumer demands. These may be due to various causes. An important cause is higher consumer income. Also important are improvements in production or in processing.

Considering consumption trends for individual animal products, we find that the trend for beef and poultry has moved upward in recent years. Most of the increase for poultry has been in broiler meat, but turkey consumption has also increased. On the other hand, consumption of fluid milk and eggs has declined appreciably.

For crop products, consumers are using more vegetables and vegetable oil. Fruit consumption has remained about steady, while the use of wheat flour has declined. These trends in consumption have been reflected in the patterns of agricultural production. — *M. B. Kirtley, Extension Specialist in Livestock Marketing*

Fall, 1977

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

IN THIS ISSUE

Rapid propagation, elimination of disease, and improved strains are possible when plants are reproduced by tissue culture (page 18).

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE Volume 19, Number 4

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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NEW FUNDING FOR AGRICULTURAL RESEARCH

Inputs into agricultural research have been gradually increasing ever since people began to realize that knowledge about provisioning mankind must be acquired more rapidly than is possible by cumulative human experience. The first great period of input increase began in the mid-nineteenth century and continued well into the twentieth. For the past 25 years, however, the rate of increase has declined in the United States.

Legislative bodies are now seeking effective means of correcting this oversight. The U.S. Congress has recently enacted the Food and Agriculture Act of 1977, which authorizes (but does not appropriate) greatly increased funding over the years for solving agricultural problems. In Illinois, the General Assembly has approved the development of new facilities for expanded research on food production. This action is clearly fitting: Sales from Illinois farms generate nearly one-fifth of the state's income annually. Each year Illinois ranks either third or fourth among the states in total annual income from farm sales and ranks first in exports of agricultural commodities.

What can the state expect from a substantially increased investment in agricultural research? Farmers benefit the most from research on the efficient use of capital, labor, and management. Consumers ultimately receive the main benefit from research resulting in greater food safety or in increased yields of crops and livestock products.

Yield increases are most likely to come from biological research. Such research has boosted yields tremendously during the past quarter century. However, this trend cannot continue indefinitely, and more and more we will need to protect what we have. Already increasing inputs are necessary just to prevent yield decreases due to plant and animal diseases, insects, and parasites.

There are signs that our present store of basic knowledge about plants and animals is depleted. Thus a large share of the nation's research investment should help re-supply scientists with new fundamental facts, particularly concerning photosynthesis, nitrogen fixation, genetic engineering, and human nutrition. The American public must realize that the promise in any new knowledge will come from more insight, more investment, and more time. But in the long run, all of America will benefit from agricultural research. — *G. W. Salisbury*

ILLINOIS COUNTY ZONING:

A proposal for clarification and change in the definition of "agricultural purposes"

C. ALLEN BOCK and FORREST G. KEATON

MANY PEOPLE consider zoning to be the most misunderstood, most maligned concept in the body of American law. A major reason is that many zoning ordinances do not accomplish a primary zoning purpose, which is to separate incompatible land uses and provide for controlled orderly growth. Zoning objectives can be accomplished only when a regulation is adopted after a logical examination of county zoning policies, then administered with those policies as prime considerations.

Zoning in Illinois

The power to regulate land use through zoning resides initially in state government unless the state constitution gives this power to certain local units. The Illinois constitution grants this power to home rule units. At present the only county home rule unit in the state is Cook County. All other counties derive the power to zone solely through authority delegated by the state legislature. The legislature has the choice of granting no zoning power, partial power, or complete zoning power.

The Illinois General Assembly has granted the counties power to adopt zoning regulations, subject to certain limitations. One of these limitations is the "agricultural exemption." Although intended to protect farmland, it has often had the opposite effect. This is the basic cause of many of the zoning difficulties in Illinois.

A lack of definition

The statute authorizing zoning regulations by the counties stipulates that the zoning power shall not "... impose regulations or require permits with respect to land used or to be used for agricultural purposes, or with respect to the erection, maintenance, repair, alteration, remodeling, or extension of buildings or structures used or to be used for agricultural purposes upon such land except that such buildings or structures ... may be required to conform to building or setback lines. ..."

Unfortunately, the statute does not define "agricultural purposes." As a result of this failure, the Illinois Supreme Court and the Illinois Appellate Courts have judicially adopted a definition of "agricultural purposes" so broad that it includes activities only tangentially agricultural. This broad definition effectively undermines the original concern for protecting agricultural land from zoning regulations.

The definition the courts use was originally adopted in 1926 in *People ex rel. Fletcher v. City of Joliet* (321 Ill. 385, 152 N.E. 159), which considered land used for agricultural purposes as it related to municipal annexation. The court defined "agricultural" as follows:

... "Agricultural" is another indefinite word which renders the statute more or less uncertain. The definition given by Webster is, "of or pertaining to agriculture, connected with, or engaged in tillage." Agriculture is defined as the "art or science of cultivating the ground including harvesting of crops and rearing and management of livestock; tillage; husbandry; farming; in a broader sense, the science and art of the production of plants and animals useful to man, including to a variable extent the preparation of these products for man's use." In this broad use it includes farming, horticulture and forestry, together with ... butter and cheese making, sugar making, etc. Unless restricted by the context, the words "agricultural purposes" have generally been given this comprehensive meaning by the courts of the county. The words "agricultural purposes" are descriptive of the nature of the use to which the land is put, and so the amount of land involved would have no bearing on the mean-

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C. Allen Bock is professor of agricultural law in the Department of Agricultural Economics and a member of the Bar of Illinois; Forrest G. Keaton is a research assistant in agricultural law in the Department of Agricultural Economics and a member of the Bar of Iowa.

ing of the words. . . . If the legislature desires to limit the application of the words to tracts containing more than two and one-half acres then it must fix the limitation. We have no authority to do so. (Citations omitted.)

Although the *Fletcher* definition originated in an agricultural setting drastically different from today's, it has continued to be used by Illinois attorney generals and courts in county zoning decisions about the exemption of land used for agricultural purposes. These decisions have effectively removed all objective criteria such as size, profit, employment, and production, from the determination of whether land is being used for agricultural purposes. Without such criteria, counties have little authority for restricting incompatible uses on agricultural land.

Three options

The General Assembly apparently has three options for improving the situation: (1) Eliminate the statutory agricultural exemption; (2) define the term "land used for agricultural purposes"; or (3) delegate authority to define this term to the counties.

The last two options seem the most feasible. Even though including a definition of "agricultural purposes" may not provide a complete answer to the problem of trying to preserve agriculture land, a sound definition would improve the current state of the law and aid in achieving county zoning goals. The question is, how should "agricultural purposes" be defined?

Requirements of a definition

A sound legal definition should reflect the policies a law is designed to promote as much as the law's substantive measures. If the agricultural exemption is intended to protect agricultural pursuits and prevent activities that jeopardize agriculture, it is unsound to define "agricultural purposes" so broadly that it includes some of the very activities that do jeopardize agriculture's continuity and land preservation. In addition, the definition should give those administering the law a way to differentiate between land uses within the definition and those outside its scope.

Protection of agriculture focuses on safeguarding agricultural productivity. Logically, then, a definition of "agricultural purposes" should insure that the alleged "agricultural" activity shows both intent and performance directed toward production.

A two-fold proposal

The following proposed definition has two objectives: (1) To give a sense of the policy protecting agricultural production through limiting incompatible uses in an agricultural zone. (2) To provide criteria by which those responsible for enforcing zoning ordinances can make well-reasoned decisions.

In accordance with the first objective, we suggest this definition of agricultural purposes: Land serves an agricultural purpose when plants are produced by tilling the soil, or through floriculture, horticulture, mushroom growing, nurseries, orchards, or forestry; or when animal products are produced through the breeding, raising, or feeding of livestock, including poultry, swine, sheep, cattle, ponies and horses, fur-bearing animals, fish, and wildlife.

These are the criteria that the enforcing officers or administering body should consider when deciding if land use is directed toward an agricultural purpose:

1. The size of the particular tract in relation to the size reasonably required to economically engage in the specified type of productive agricultural activity.

2. Sale of produce or livestock from the activity.

3. Type of land to be used (soil type, slope, etc.).

4. Percentage of time spent in employment elsewhere by the person seeking to have the activity classified as agricultural, percentage of income received from other activities, and plans of the person to employ other qualified and experienced persons to do the agricultural work on the tract under consideration.

5. Association of the planned use of the tract with a tract already being used for an agricultural purpose.

6. Amount of profit from the activity, if any, and the history of profits from the activity or like activities engaged in by the landowner.

7. Manner in which the landowner carries on the activity (that is, whether the activity is conducted in a businesslike manner and is substantially similar to other activities of the same nature, and whether operating methods, techniques, and equipment are consistent with intent to engage in productive agricultural activity).

8. Specific uses to which the land is or will be put (that is, production, pleasure, service, or consumption).

9. Qualification of the tract under soil conservation programs and other federal or state agricultural programs.

The first part of the preceding definition requires that land use be "in the ball park" of one of the agricultural activities listed (for example, tillage of the soil, floriculture, raising livestock). The second part focuses on separating a proposed agricultural use that is productive from one that is unproductive, even though it has met the initial "ball park" requirement.

The nine criteria listed are not absolute requirements — that is, they do not all have to be met to classify a proposed land use as productive agriculture. Neither do the criteria have to be given equal weight in the decision. However, the decision-making officer or body should evaluate the final effects of all nine factors and incorporate a description of this evaluation into the decision.

Not a fundamental change

Defining "land used or to be used for agricultural purposes" does not require a fundamental change of Illinois zoning structure. But the county zoning authorization does need a sound, clarifying definition of "agricultural purpose" that can preserve zoning effectiveness, particularly if the county wants to preserve its farmland.

Rural Renaissance in Illinois

JAMES D. WILLIAMS

FOR THE FIRST TIME in this century, the nation's nonmetropolitan counties are growing faster, on the average, than the metropolitan counties. While the nonmetropolitan counties have shown a revived ability to attract new residents and retain population, metropolitan areas are stagnating or declining. A recent study indicates that Illinois is undergoing some of the same changes that are occurring nationwide.

The units of analysis for the Illinois study were the state's 102 counties. They were classified in various ways according to several characteristics. For each grouping of counties, annual rates of population change and net migration for 1960-1970 were compared with 1970-1975 figures.

Population data for 1960-1970 were taken from standard Census of Population sources. Data for 1970-1975 were obtained from a recent series of annual population estimates put out by the Bureau of the Census. It includes 1975 county population estimates, 1970-1975 net migration estimates, and revised and corrected 1970 county population figures.

While based on estimating equations and not censuses or surveys, these post-1970 data have been shown to be quite reliable when aggregated. Estimates for any individual county, however, may contain some significant error and should be viewed with caution.

Patterns by metropolitan status

Twenty-three counties in Illinois are classified as metropolitan; 79 as nonmetropolitan. Metropolitan counties are those included in a Standard Metropolitan Statistical Area (SMSA) as of February, 1975. Illinois has 10 SMSAs (Fig. 1).

While in the nation nonmetropolitan areas are growing faster than metropolitan areas, in Illinois both sectors have been virtually stagnant since 1970 (Table 1). However, comparing annual growth rates in 1970-1975 with those in the 1960's, we can see some dramatic changes. Although growth in both sectors has declined, the decline has been much greater in metropolitan counties. For metropolitan counties, the growth rate has declined by more than 1 percentage point (from 1.15 to 0.06 percent); for nonmetropolitan counties, by only two-tenths of a percentage point.

Population change has two components: (1) natural increase (or decrease), which is the difference between births and deaths; and (2) net migration, or the difference between the number moving into an area and the number leaving. The declining birth rate partly explains the slower population growth in both metropolitan and nonmetropolitan counties. However, it affects both sectors about equally and does not account for the significantly greater decline in the growth of metropolitan counties. To explain this difference, we must examine changes in the annual rates of net migration.

In the last two columns of Table 1, we find that metropolitan counties had a slight net in-migration in the 1960's, but a substantial net out-migration after 1970. Nonmetropoli-

James D. Williams is a research assistant on a project entitled "Rediscovery of Rural America." It is funded by the North Central Regional Center for Rural Development and the Illinois Agricultural Experiment Station.

Table 1. — Population Change and Net Migration by Selected County Characteristics

County characteristics	No. of counties	Population			Annual rate of pop. change		Net migration		Annual rate of net migration	
		1960	1970	1975	1960-'70	1970-'75	1960-'70	1970-'75	1960-'70	1970-'75
			(000)		(pct.)		(000)		(pct.)	
Metropolitan[a]	23	8,073.9	9,055.9	9,082.4	1.15	.06	17.0	−318.5	.02	−.67
Core	10	6,515.2	7,039.0	6,923.5	.77	−.31	−224.9	−364.5	−.33	−.99
Fringe	13	1,558.7	2,016.9	2,158.9	2.56	1.29	241.8	46.0	1.35	.42
Nonmetropolitan	79	2,007.3	2,056.9	2,063.4	.25	.05	−59.3	−24.0	−.29	−.22
Adjacent to SMSA	35	1,149.1	1,193.3	1,193.6	.38	.00	−31.5	−23.1	−.27	−.37
SLP 10,000 or more[b]	11	614.8	639.3	633.2	.39	−.18	−21.0	−20.3	−.33	−.60
SLP less than 10,000[c]	24	534.3	554.0	560.4	.36	.22	−10.5	−2.8	−.19	−.10
Nonadjacent	44	858.2	863.6	869.8	.08	.10	−27.8	−.9	−.32	−.02
SLP 10,000 or more	8	321.2	350.7	351.7	.88	.05	10.6	−4.5	.32	−.24
SLP 2,500-9,999	24	452.8	432.7	436.1	−.42	.09	−31.6	2.5	−.71	.11
Entirely rural	12	84.2	80.2	82.0	−.49	.43	−6.8	1.1	−.83	.23

[a] Metropolitan status as of 1975. [b] Size of largest place as of 1970. [c] Includes one entirely rural county.

tan counties show net out-migration in both periods, but the rate of out-migration has declined from 0.29 to 0.22 percent a year. The out-migration from both sectors since 1970 reflects the fact that Illinois lost about 342,000 people to other states in the first half of this decade.

Patterns in metropolitan areas

Metropolitan areas contain two types of residential environments, which often show very different population patterns: central city areas and suburban areas. The distinction between these two can not be precisely pinpointed by using counties as units of analysis. However, an approximation can be made by dividing SMSA counties into those containing the major cities (core counties) and the surrounding or fringe counties.

As in many parts of the country, Illinois's central city or core counties are losing population through out-migration at an increasingly rapid rate. During the 1960's net out-migration in these counties was moderate, but the population was still growing because of natural increase (Table 1). Since 1970, however, net out-migration has amounted to nearly 1 percent a year, outpacing natural increase and resulting in an overall population loss.

Fringe counties, approximating suburban areas, continue to show a high rate of annual growth, but it has declined from 2.56 percent to 1.29 percent. This decline is largely due to the rather large drop in the rate of net in-migration (from 1.35 percent a year to 0.42 percent). Thus, even "suburban" areas appear to be entering a period of less rapid growth than seen in past years.

Nonmetropolitan trends

Historically, cities have expanded outward from their centers, with urbanization spreading into adjacent nonmetropolitan counties. Eventually these counties have been reclassified as metropolitan.

To see whether urban sprawl is affecting new population patterns, the 79 nonmetropolitan counties have been divided into those that are adjacent to an SMSA and those that are not. From Table 1 we find that population growth followed the expected pattern in the 1960's, being greater in adjacent counties than in nonadjacent counties. Both groups experienced net out-migration in the 1960's, but the rate was somewhat higher for the nonadjacent areas. In 1970-1975, however, this trend was reversed. Net out-migration increased in adjacent counties and decreased in nonadjacent counties, so that the growth rate was higher in the nonadjacent counties. In fact, adjacent counties did not grow at all. These trends suggest that nearness to an SMSA is no longer a stimulus to population growth.

Another factor that historically has helped to clarify nonmetropolitan population patterns is the level of urbanization in a county. The presence of a large town has often induced growth in nonmetropolitan counties. The relationship between county population trends and the size of the largest place in the county (SLP), as reported in the 1970 Census, was therefore analyzed.

Population trends in the 1960's did follow the expected pattern: Those nonmetropolitan counties, both adjacent and nonadjacent, that had the larger towns had the higher growth rates (or less rapid declines). In 1970-1975, however, this trend was completely reversed, with the higher growth rates occurring in the less urbanized counties. Similarly, the effect of urbanization upon net migration was reversed in nonadjacent counties. Entirely rural counties — those with no towns over 2,500 and no proximity to an SMSA — have shifted from fairly rapid net out-migration to a net in-migration of 0.23 percent per year, and from overall population loss to population growth. This turnaround, startling though it seems, fits into the national pattern of rural population growth.

Changes favor commuter counties

The growth of counties not adjacent to metropolitan areas suggests that the new patterns can not be accounted for by employment decentralization and suburbanization around metropolises. However, if we expand our notion of suburbanization to all counties where a high

Table 2. — Population Change and Net Migration by Further Selected County Characteristics for Nonmetropolitan Counties

County characteristics	No. of counties	Population			Annual rate of pop. change		Net migration		Annual rate of net migration	
		1960	1970	1975	1960-'70	1970-'75	1960-'70	1970-'75	1960-'70	1970-'75
		(000)			(pct.)		(000)		(pct.)	
Percent working outside county of residence, 1970										
Less than 10 percent	13	599.5	630.9	627.6	.51	−.10	− 9.1	−15.0	−.15	−.45
10-19.9 percent	24	621.8	625.3	623.5	.05	−.05	−28.5	−10.7	−.46	−.33
20-29.9 percent	26	548.7	547.8	548.2	−.02	.01	−23.4	− 4.2	−.43	−.15
30 percent or more	16	237.2	253.0	264.1	.64	.82	1.6	5.9	.07	.43
Percent employed in manufacturing, 1970										
Less than 20 percent	29	518.3	519.2	525.3	.02	.22	−15.5	3.6	−.30	.13
20-29.9 percent	38	1,003.6	1,028.0	1,028.0	.24	−.01	−28.4	−15.0	−.28	−.28
30 percent or more	12	485.3	509.3	510.1	.48	.03	−15.4	−12.6	−.31	−.47

proportion of the population is working in another county, we are then including the possible effects of suburbanization around smaller cities.

In the first section of Table 2, nonmetropolitan counties have been classified according to the percentage of employed population working outside the county of residence as of 1970. Counties with more than 30 percent of the population commuting to another county clearly had the most favorable migrational status during both periods of the study. Many of these counties have no large towns and are not adjacent to metropolitan areas. It would seem, then, that what we are seeing is migrational growth in less populous counties located near other counties with nonmetropolitan urban centers.

Industrial employment

One might expect the pattern of change to favor the highly industrialized nonmetropolitan counties. However, the opposite appears to be true. Counties with the least dependence on manufacturing showed a net in-migration of 0.13 percent in the 1970's in contrast to a net out-migration of 0.30 percent in the 1960's (Table 2). In highly industrialized counties net out-migration increased from 0.31 percent to 0.47 percent. If new migration patterns are a response to the growth of manufacturing employment in nonmetropolitan areas, then that growth must be occurring in counties that did not have much manufacturing to start with.

Geographic pattern of change

Much of the interest in the national revival of nonmetropolitan population growth has focused on "turnaround" counties. These counties show either net in-migration in the 1960's and net out-migration in the 1970's (negative turnaround) or net out-migration in the 1960's and net in-migration later (positive turnaround).

Illinois counties showing positive turnaround are clustered in the south-central part of the state and are all nonmetropolitan (Fig. 1). Negative turnaround counties are more dispersed and include both SMSA and nonmetropolitan counties.

But turnaround counties represent only a small part of the trend. A county may achieve turnaround status by simply going from a very slight net out-migration to very slight in-migration. A better indication of the direction and degree of change, as well as the level of acceleration or deceleration, may be obtained by subtracting the annual rate of net migration for 1960-1970 from that for 1970-1975. For instance, DuPage County's annual rate of net migration was 3.141 percent in 1960-1970 and 0.979 percent in the early 70's, for a negative change of 2.162 percentage points.

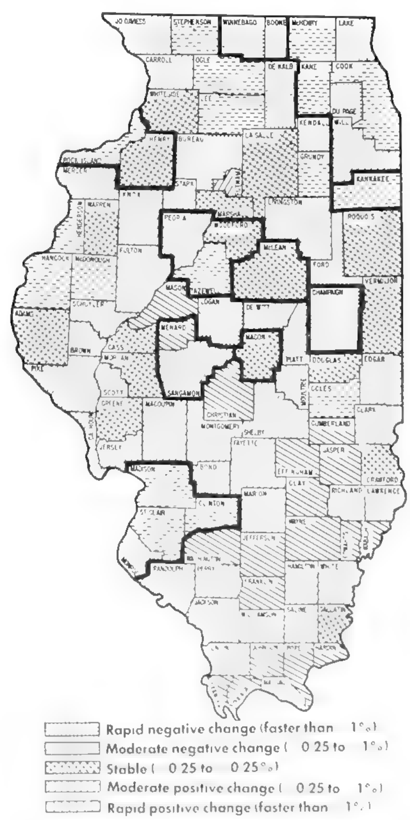
Figure 2 shows the level and direction of change in net migration for Illinois counties. Keep in mind that a positive change results from any of the following: less net out-migration in the 70's than in the 60's, positive turnaround, or more net in-migration in the 70's. Negative changes result from opposite trends.

Looking at Figure 2, we find rather bleak prospects for the larger SMSAs in the state. Negative change is evident in the Illinois portion of the St. Louis metropolitan area; the Rockford, Kankakee, and Champaign SMSAs; and all of the Chicago SMSA except Will County, a fringe county. In contrast, SMSAs in the center of the state generally show positive change in their ability to attract and retain population. Most significant is the heavy concentration of positive change counties in the nonmetropolitan southern half of the state.

A real trend

Most probably, the recent changes in population trends represent the culmination of a number of forces that have slowly gathered momentum over the past few years. Further analysis is required, especially to determine how much of the new trend is attributable to "push" factors in urban areas, and how much to "pull" factors in less urban areas. The fact that nearly all states show changes that favor the nonmetropolitan sector suggests a definite trend.

"Turnaround" counties — direction of net migration reversed after 1970. Heavy lines indicate SMSA boundaries. (Fig. 1)



Changes in annual rates of net migration between 1960-'70 and 1970-'75. (Fig. 2)

Atmospheric Ammonia Affects Swine Health

S. E. CURTIS, J. G. DRUMMOND, and J. SIMON

SWINE raised in closed houses are subjected to an environment quite unlike their natural one, with little opportunity to seek more favorable surroundings. Confinement thus intensifies the relationship between the animal and its environment — particularly air. In closed houses, the pig's respiratory tract is continuously exposed to air pollutants.

Swine-house air pollutants of major concern include dust and gases, such as ammonia and hydrogen sulfide. They may affect pig performance both directly (by altering metabolic reactions) and indirectly (by influencing pig health). Air-pollution research at the University of Illinois has aimed at studying these direct and indirect effects, with special emphasis on ammonia.

Most of our experiments have been carried out in four dynamic-type air-pollutant exposure chambers constructed of stainless steel and glass (Fig. 1). Each chamber has 16 square feet (1.69 square meters) of floor space and can hold four pigs weighing up to 100 pounds each, or two up to 200 pounds. Pollutants can be introduced into the prefiltered intake air of each chamber.

Initial trials

Our initial experiment consisted of seven trials focused on determining the effects of aerial ammonia, hydrogen sulfide, and swine-house dust — separately or in various combinations — on the health and performance of growing pigs.

The concentrations of air pollutants introduced into the exposure chambers were similar to those commonly encountered in commercial swine houses: ammonia, 50 parts per million (ppm) or less; hydrogen sulfide, 10 ppm or less; dust, 10 milligrams per cubic meter or less. Animals were continuously exposed to the test environments for as long as 109 days, except for one short period (5 minutes or less) each day when the chamber was cleaned. All pigs were killed and subjected to postmortem examination at the end of each trial.

From the results of the trials (Table 1), we concluded that these air pollutants, at levels and in combinations resembling those in closed swine houses, had essentially no direct effects on the pigs' rate of body-weight gain or respiratory-tract structure. However, our findings did not preclude the possibility that air pollutants influence respiratory-tract disease in the pig.

Pulmonary bacterial clearance

At about the same time, we developed a technique for measuring pulmonary bacterial clearance in young pigs. The animals are held for 10 minutes in a special chamber smaller than the ones previously described (Fig. 2). During this time, tracer bacteria (a nonpathogenic strain of *Escherichia coli*) are introduced into the atmosphere as a fine mist. Thus the pigs' lungs are loaded with bacteria as a consequence of normal breathing.

The animals then spend 2 or 3 hours in one of the larger chambers with an atmosphere of either filtered air or filtered air plus pollutant. After this clearance period, the numbers of live bacteria remaining in the lungs are measured to determine any influence of the air pollutant on clearance of bacteria from the lungs. It is as-

Table 1. — Treatments and Rate-of-Gain Data for Swine in Seven Air-Pollutant Exposure Trials

Trial	Mean body wt. at beginning of trial (kg)	Duration of trial (days)[a]	Air pollutant	Desired level[b]	No. of pigs	Mean daily body-wt. gain (kg)
I	10.9	26, 33, or 40	Control	....	8	.64
			NH_3	50 ppm	8	.62
II	8.2	27	Control	....	4	.48
			NH_3	50 ppm	4	.50
			Dust	10 mg/m^3	4	.51
			NH_3 + dust	(above)	4	.49
III	31.8	24, 57, or 71	Control	....	4	.69
			NH_3	50 ppm	4	.67
			Dust	300 mg/m^3	4	.64
			NH_3 + dust	(above)	4	.62
IV	8.2	57	Control	....	8	.52
			NH_3 + dust	50 ppm 300 mg/m^3	8	.42*
V	9.1	46, 78, or 109	Control	....	8	.54
			NH_3	75 ppm	8	.55
VI	13.2	17	Control	....	3	.58
			H_2S	8.5 ppm	3	.53
VII	20.9	19	Control	....	3	.54
			H_2S + NH_3	2 ppm 50 ppm	3	.52

[a] In some trials, pigs were sacrificed at more than one time for the purpose of either determining respiratory-tract status after various exposure periods or making space for the remaining pigs to grow for a longer experimental period.
[b] The levels of air pollutants in the exposure chambers were always within the range of ±10% of the desired level.
* The difference in the rate of body-weight gain between pigs on the two treatments was significant ($P < .10$) when the data were adjusted by covariance analysis for initial body weight.

S. E. Curtis is associate professor of animal science; J. G. Drummond, graduate research assistant; and J. Simon, professor of veterinary pathology and hygiene.

Table 2. — Rate of Gain for Swine in Ascarid-Ammonia Trials[a]

Treatment	Mean daily gain, kg.
Control	.46
Ascarids (50,000 embryonated ova given on first day of trial)	.36
Ammonia (100 ppm)	.35
Ascarids + ammonia (same rates as above)	.29

[a] Ten pigs per treatment.

Table 3. — Rate of Gain for Swine in Ammonia Dose-Response Trials[a]

Treatment	Mean daily gain, kg.
Control	.44
Ammonia (50 ppm)	.44
Ammonia (100 ppm)	.31
Ammonia (150 ppm)	.33

[a] Six pigs per treatment.

sumed that a reduction in the rate of clearance would reflect a greater predisposition of the lungs to bacterial infection.

We found that atmospheric ammonia at concentrations of 50 or 75 ppm lowered the young pig's ability to clear its lungs of the bacteria. We therefore concluded that air pollutants might predispose the pig to infections of the respiratory tract.

Ascarid-ammonia trials

On the basis of the bacterial-clearance trials, we set out to develop a model system for studying effects of the air environment on the onset and course of pneumonia in the young pig. Migration of large roundworm (*Ascaris suum*) larvae through the lungs is often associated with the early stages of pig pneumonia in the field. Thus, our first step in model development involved ascarids and aerial ammonia.

Several ascarid-ammonia trials, each lasting 4 weeks, were conducted with young pigs weighing about 15 pounds at the start. Pigs inoculated with 50,000 embryonated ascarid ova or continuously exposed to 100 ppm of aerial ammonia gained about one-fourth less body weight than did control animals. In pigs that were inoculated with ova and also exposed to ammonia, the weight gain was reduced by about one-third (Table 2). Hence, effects of the ascarids and air pollutant were additive.

Ammonia dose-response trials

Although exposure to 100 ppm of ammonia in the ascarid-ammonia trials reduced pigs' rate of gain, exposure to 50 or 75 ppm had not affected performance significantly in the first experiment (Table 1). This prompted us to conduct a series of 4-week dose-response trials involving four concentrations of aerial ammonia: 0, 50, 100, and 150 parts per million.

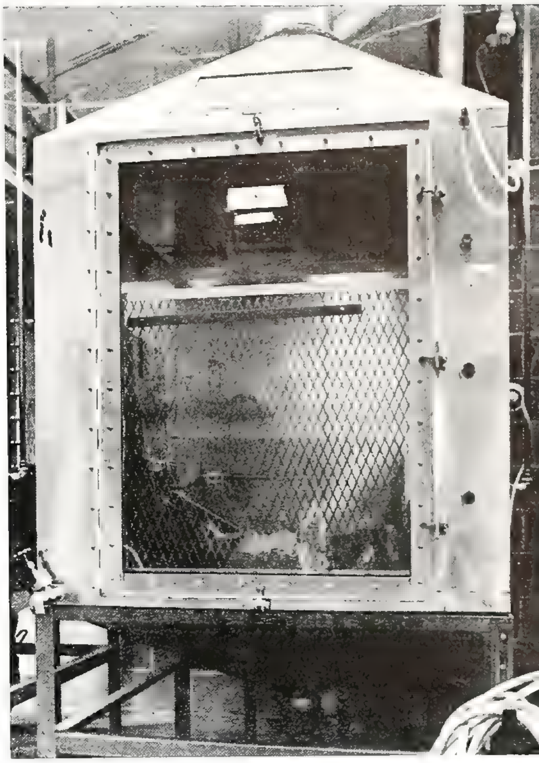
This experiment began with pigs weighing about 18 pounds. Those held in an atmosphere containing 50 ppm of ammonia gained as well as the control animals, confirming our findings in the initial experiment (Table 3). Exposure to 100 ppm depressed rate of gain as it had in the ascarid-ammonia trials. However, increasing the ammonia concentration to 150 ppm did not cause a further decrease in rate of gain.

It appears from these results that the threshold concentration for a detectable effect of aerial ammonia on a healthy pig's ability to gain weight lies somewhere between 75 and 100 ppm. A further conclusion is that a pig's response to increasing concentrations of aerial ammonia is not linear.

Studies to continue

Thus far we have established three main facts about atmospheric ammonia in the pig's environment: At 50 or 75 ppm it hinders the young pig's ability to clear bacteria from the lungs; somewhere between 75 and 100 ppm, it depresses the rate of gain; and at 100 ppm it exacerbates the effects of the early stages of ascarid infection.

In future studies we plan to add one or more pulmonary-pathogenic microbes to the challenges of early ascarid infection and atmospheric ammonia. The results will ultimately be used in the design and operation of swine housing that will provide an environment conducive to optimal health and performance.



Air-pollutant exposure chamber. (Fig. 1)

Pigs in this special chamber are exposed to a bacteria-containing mist. (Fig. 2

MANAGEMENT BY EXCEPTION:

A program for efficient livestock production

H. B. PUCKETT, E. F. OLVER, and K. E. HARSHBARGER

THE EYE of the herdsman has long been called the most effective production aid of the livestock producer. A herdsman's ability to achieve high performance for a given species is related to his knowledge of the animals, his memory, and his attention to detail.

The importance of the herdsman is illustrated by a study conducted in England several years ago. Dairy cows' long-time production records were tabulated on an estate where the manager routinely shifted herdsmen to different herds every few years. High-producing herds were expected to continue producing well, regardless of the herdsman. However, this hypothesis was disproved: The tendency for high production followed the herdsman, not the herd.

But no matter how good the herdsman, the number of animals to which he can give individual attention has until now been limited by his memory. When the herdsman's memory is overtaxed, herd performance suffers, more animals get sick, and dairy cows' "dry periods" last longer.

A new approach to herd management would augment the herdsman's memory by utilizing the capacity of the electronic computer to collect, store, and analyze large amounts of data. The computer would single out the animals that were in some way varying from the norm, thus identifying the ones needing individual attention and greatly increasing the number that one herdsman can efficiently handle. The whole concept of singling out the animals needing special care is called "management by exception."

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Need for better management

"Management by exception" may be applied to any livestock species that is handled in groups. However, our present research is concentrated on dairy cattle. It is part of a general program to help the dairy industry attain the following goals:

1. Preserve and improve the efficiency of the dairy cow as a converter of forage into high-quality human food.
2. Increase the income-producing ability of the dairy farmer and dairy worker.
3. Reduce the labor input for milk production without sacrificing the performance of the cow.
4. Increase the dairy farmer's real income without increasing the relative cost of milk and milk products to the consumer.

These goals are not all compatible at this time. For example, the cost of labor is sure to increase and it is reasonable to expect that agricultural workers will seek wages and fringe benefits comparable to those of industrial workers. If herdsmen are restricted to a 40-hour week with no split shifts, production costs and consumer prices are bound to rise sharply unless a more efficient system of dairy production is developed.

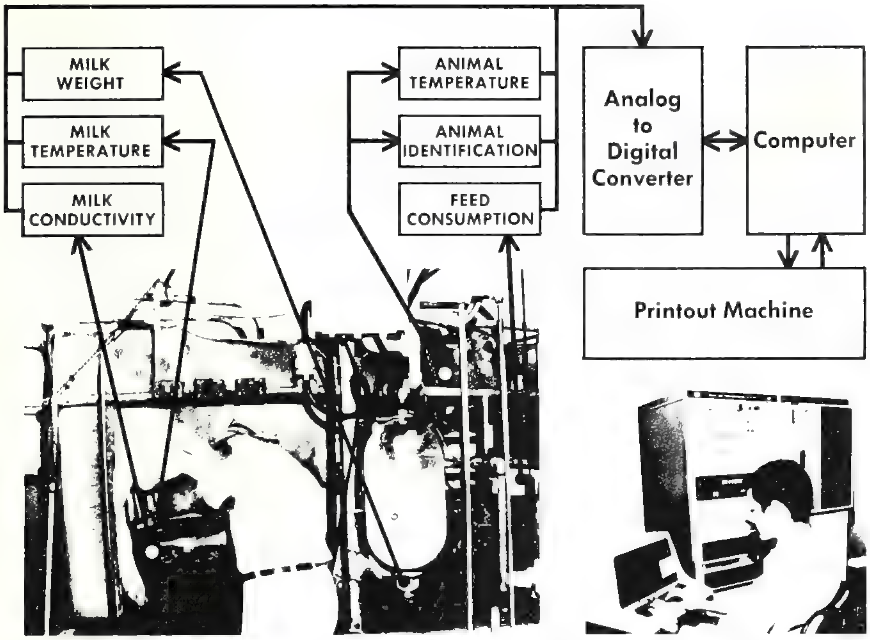
Automation of milking and feeding has probably been carried as far as is practical. We now have automatic group and individual animal feeding systems. Removal of the milking claw, or teat cluster, after milking is perhaps the last easily mechanized operation. Dairymen who have installed automatic milking claw removal units have increased the milking rate from 50-60 cows to 100-105 cows per milker man-hour.

Probably the only direct man-to-cow action that remains to be mechanized in the milking operation is attachment of the milking claw. However, mechanizing this action would be difficult and expensive. It might also increase the number of cows per herdsman far beyond the number that can be efficiently handled with current practices.

At present, 50 to 60 cows represent a practical limit for one man — not because he can't milk more but because his memory is overtaxed. Each time the average number of cows per herdsman has increased, meaning less individual attention to the cows, the cows' performance has usually decreased.

Until now, the reduced labor cost has more than offset a decline in production efficiency. But this cannot be expected to continue indefinitely. For greater herd productivity, we need to increase the efficiency of management.

With a computerized management-by-exception system, it will no longer be necessary to sacrifice production efficiency for labor-saving devices. As the computer directs the manager to those cows needing special attention, he will be able to care for the health of perhaps 20 times the number that he otherwise could. He will be able to make timely, accurate management decisions that will reduce the incidence of disease, increase production through more exact feeding, shorten the dry periods, and improve selection of replacement stock. As workers are freed from the need to keep a close eye on each cow, they will be able to specialize, further increasing labor productivity.



For the dairy herd, management by exception requires equipment that automatically collects information about the cow, milk, and feed consumption, plus a small computer that stores the information, makes comparisons, and prints out results.

Development of system

Automatic recording of production and physiological data is possible with present technology, but this is of little value unless the data are automatically associated with the proper animal. Hence a means of identifying the individual animal electronically is essential for the system to work. We expect to do this with transponders on the cow's neck, or possibly imbedded under the skin.

The computer then needs to be programmed so that it will accept the input data, perform the analyses, and execute the required outputs. In addition to the cow's identity, the necessary inputs include milk conductivity, temperature, and weight; feed consumption; and animal temperature, which we expect to obtain from the transponder attached to the cow.

Developing all of this computer software will be time-consuming, but it will be very worthwhile for more efficient dairy production.

Costs vs. benefits

A good level of milk production is 14,000-15,000 pounds a year. However, the average U.S. cow produces about 10,500 pounds, and in one large dairy visited average production was 11,000 pounds. If improved management could increase this herd's production by 3,000 pounds per cow, $150 additional income per cow above feed costs would be engendered, assuming the price of milk to be 10 cents a pound. A herd of 500 cows would return an additional $75,000 a year above feed costs.

At current market prices, a computer system with full data-handling and control capabilities would cost about $100,000 and would be adequate for a herd of 500 milking cows. Assuming that this investment could be amortized over a 10-year period at a 12-percent rate and that the maintenance would amount to 10 percent of capital, the annual cost of ownership would be $27,217, or less than 37 percent of the anticipated gain in productivity. Increasing the capacity of the computer system for a larger herd would cost less than 25 percent of the original cost per animal; therefore, it would be more economical for larger herds.

With further development of the system, the cost could be expected to drop to about $45,000 and be economical for herds of about 200 milking cows.

A computerized management-by-exception system would not have to be adopted all at once. Even for herds with fewer than 200 cows, the owner might start with an economical system of identifying the cow and indicating her body temperature. This would probably improve management enough to pay for itself. Once the system is begun, small sections can be added, as the benefit versus cost ratio permits, to include automatic feeding and production recording. The full capability can be implemented when herd size warrants, probably when it exceeds 200 animals.

With this type of system, herd size will probably be determined more by financial restraints and desired labor use patterns than by the herdsman's memory capacity.

Research goals

Current University of Illinois research on management by exception has the following goals:

1. To help develop an electronic system of animal identification.

2. To develop an operating system for recording and analyzing data automatically, using currently available hardware, and to construct primary sensors for milk weight, milk conductivity, and milk temperature.

3. To develop computer software for effectively using the physiological data that can be made available to the computer system automatically twice each day. This is essential to the success of the concept.

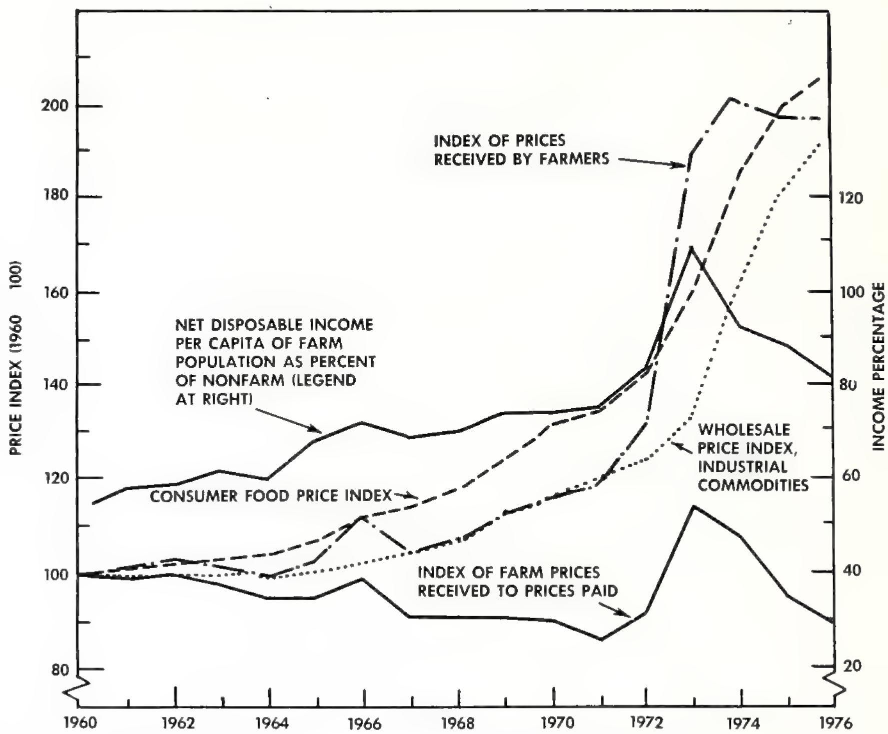
Progress is being made toward these objectives. A commercial prototype of an electronic animal identification system is expected to be available before the end of the year. Some time during the winter of '77-'78 a small computer with an automatic data-collection capability will be installed at the University dairy farm. The instrumentation is to be completed by mid-1978, so that we can start collecting the data needed to make electronic "management by exception" a reality for the dairy farmer.

The 1977 Food and Agriculture Act

R. G. F. SPITZE

THE FOOD AND AGRICULTURE ACT of 1977, which became law in September, is the latest in a long succession of public policies affecting farm income and food prices.

The first such policy was embodied in the Agricultural Marketing Act of 1929 (Federal Farm Board). Later acts have included the 1933 Agricultural Adjustment Act and, most recently, the 1973 Agriculture and Consumer Protection Act. This policy stream represents continuing efforts to solve some persistent problems.



Agricultural price and income trends in the United States since 1960. (Fig. 1)

Price and income problems

Among the problems plaguing agriculture are unstable prices and incomes (Fig. 1). Prices received by farmers vary more than wholesale prices generally, and are reflected in food prices that are slightly more unstable than consumer prices as a whole. Since 1960, total per capita income for farm people has varied from 58 to 109 percent of the nonfarm. Through most of the 1960-1976 period, the prices that farmers paid went up faster than the prices they received. In 1973 and 1974, however, prices received and income were at record favorable levels.

Future price and income levels are related to the balance between U.S. agricultural supply and demand. In 1976 agricultural output increased by 2.6 percent, while population grew by 0.7 percent and rising incomes further increased demand by an estimated 0.4 percent. The rest of the supply increase was available for new net exports and government purchases. However, net exports showed no real increase so that a 1.5-percent increase in supplies was not met by a comparable increase in demand.

According to price elasticity concepts, such a margin would be expected to cause a price erosion of over 5 percent. In fact, farm prices declined 6 percent during 1976 and total net farm income also dropped, emphasizing the need for a continuing food and agricultural policy.

Two other situations stimulated legislative action on agricultural and food issues: A worldwide concern about food was dramatized in the World Food Conference; and groups like the Senate Committee on Nutrition were calling attention to nutritional deficiencies at home.

As a final impetus to passage of a new act, the 1973 act was due to expire on December 31, 1977. This meant that P.L. 480 was facing termination, and that grains, cotton, dairy, and wool programs would revert to an earlier policy of higher price supports and no effective production control, which few people wanted.

Implications

The 1977 act will last four years. Following a path charted in the early 1960's, it provides for price supports, direct payments, voluntary production control, and domestic and foreign food aid. Other items include target prices to reflect cost of production; a 3- to 5-year government-farmer reserve; discouragement of grain embargoes; and expanded research and extension funds. Chief purposes are: (1) to stabilize prices and give income assistance to farm producers; (2) to make food available to domestic consumers through an assisted and stabilized market; and (3) to make agricultural exports available through price stabilization, reserves, and assistance.

The main provisions and implications of the act are summarized on the following page.

R. G. F. Spitze is professor of agricultural economics.

SUMMARY OF PROVISIONS OF 1977 ACT

ITEM	PROVISIONS	IMPLICATIONS
DURATION	Four years, 1978-1981.	Issues settled for few years.
FOOD DISTRIBUTION Domestic	Food stamp program continued. Maximum $6.2 bil./yr. budgeted. Partial purchase requirement for stamps eliminated. Work requirement for able recipients to be eligible. Benefits reduced for high and raised for low income.	Slows cost escalation. Increases participation. Serves needy better. Simplifies administration. Attempts to reduce fraud.
	Women, infants, children (WIC) program continued.	Improves nutrition of pregnant women and infants.
Foreign	"Food for Peace," P.L. 480 continued. Requires more reporting of bids, payments, sales. Permits distribution of products not in "surplus."	Attempts to reduce fraud. Permits food aid in addition to just surplus disposal.
GRAIN RESERVES	Farmer-held reserve mandated with some discretion for Sec. 3-5 yr. extended loans available for grains. Wheat extended loan reserve must be 300-700 mil. bu. Reserve may be induced by free storage and interest. Farmer redemption of loans may be discouraged by penalty when prices below 140% loan, may be induced by fewer benefits when prices 140-160% loan, and forced when prices 175%. Govt. stocks resalable at 115% loan if no outstanding loans of that product; 150% otherwise.	Insures govt.-farmer controlled reserve for security of consumer, export market, and aid. Permits recall loans and resale govt. stocks during high prices and low reserves. Reduces high and low extremes of farm prices.
COMMODITIES Wheat	Price support (non-recourse loan), minimum: 1977 — $2.25/bu. 1978-81 — $2.35/bu. (may be lower by 10%/yr. to $2.00 if supplies heavy)	Increases stability of producer and consumer food prices. Results in stocks and possible reserves. Raises minimum export prices and provides stocks for possible exports.
	Target price assures national aver. return on planted acres within farm allotment to producers meeting any set-aside and other conditions: 1977 — $2.90/bu. 1978 — $3.05/bu. (1.8 bil. bu. harvest or less) — $3.00 (more than 1.8 bil. harvest) 1979-81 — escalates with rise in variable costs.	Maintains minimal producer incomes at levels somewhat related to rising costs of inputs. Results in variable govt. payments to producers.
	Set-aside out of current year's planted and normal crop acreage may be a condition for benefits: 1978 — 20% set aside (by Secretary of Agriculture)	Reduces large supplies relative to demand by voluntary action.
	Disaster payments available 1978-79 if plantings prevented and yields low due to natural occurrences.	Govt. payments reduce producer risk due to nature.
Corn (support on other feed grains proportional)	Price support (non-recourse loan), minimum: 1977 — $2.00/bu. 1978-81 — $2.00/bu. (as wheat, may be lowered to $1.75) Target price (same conditions as for wheat) 1977 — $2.00/bu. 1978 — $2.10/bu. 1978-81 — As wheat, will escalate with costs. Set aside out of current year's planted and normal crop acreage may be a condition for benefits. Approach to disaster payments same as for wheat.	Implications are same as for wheat, with price support also increasing stability of livestock prices.
Soybeans	Price support only, minimum: 1977 — $3.50/bu. (by Secretary of Agriculture) 1978-81 — Loan mandated but level at discretion of Sec.	Same as for corn, but no minimum mandated.
Cotton, rice, peanuts, sugar	Price support loans, target prices and/or set-aside established for each commodity	Effects similar to above but vary with combinations.
Payment limitations	Combined wheat, feed grain, cotton target payments limited (rice higher): 1978 — $40,000; 1979 — $45,000; 1980-81 — $50,000	Inducement for large producers to set aside is proportional to height of limit — and so are equity concerns.
Dairy	Price support dairy products continued, minimum: Until March 31, 1979 — 80% to 90% parity After March 31, 1979 — 75% to 90% parity Adjusted semiannually through March 31, 1981.	Same as for wheat, but effects are more direct to food consumers.
Wool and mohair	Price deficiency payments continued for all production at 85% of formula rate (figures at about 99¢/# for 1977).	Govt. payments to producers. Less dependence on imports.
RESEARCH AND EXTENSION	Funding ceiling increased for 5 years, emphasis on competitive grants, USDA lead role, human nutrition, veterinary schools, small farm help, 1890 colleges, solar energy, alcohol extraction, advisory groups roles.	Increases food and agriculture funds, relying more on grant approach and centralized administration.
ADDITIONAL ITEMS Export embargo	Secretary must raise price support to 90% parity upon suspension of normal exports of product with loan program.	Discourages public disruption of commercial exports.
Multi-year set-aside (if necessary)	Secretary may have multi-year set-aside contracts for feed grains, wheat, cotton.	Encourages permanency, conservation, sediment control.
Farm storage	Loans for farm product drying, storage, and handling.	Encourages loans and reserves.
Conservation	Funding eased for major soil conservation projects.	Encourages erosion control.
Grain inspection	Funding for grain inspection supervision.	Facilitates new program.

Returns on Corn-Soybean Farms, And Implications for Land Values

JOHN T. SCOTT, JR.

Congress and the Administration have decided on farm price support programs at a time when prices of agricultural commodities, particularly wheat and corn, are down. If farmers respond to current price conditions by reducing their corn acreage and growing substantially more soybeans, then soybean prices could also be lower a year from now. Given these falling prices, it is especially important to know the costs of production when formulating and evaluating government price programs.

Net returns on corn and soybean farms depend upon a number of factors affecting gross returns and costs. Essentially, yields and prices determine gross returns. Yields depend on such factors as the level of available technology, management, and weather. The cost side of the net return equation consists of several general items, each of which can be further broken down into its component parts.

To provide information for those interested in price policies and associated programs, we have studied the average cost per acre for various inputs used to produce corn. The study is an update of one that A. G. Mueller and R. A. Hinton did two years ago, using 1974 data. An update was considered necessary because of rising costs since 1974, as well as changes in the inputs used.

FBFM records analyzed

For the study, we had access to the 1976 records of approximately 7,800 commercial farmers throughout Illinois. These farmers are cooperators with the University of Illinois through the Illinois Farm Business Farm Management Association.

About 5 percent of the records were found to be unusable. Another cut was made by eliminating farms with average soil ratings below 85 in northern Illinois (generally north of the Wisconsin terminal moraine) and below 75 in southern Illinois, where soils are more weathered. (The best soils in Illinois have a rating of 100 based on long-term grain yields.)

To minimize the problem of allocating costs in multi-product firms, a final sort was made to get almost pure grain farms. Only farms were retained where less than 10 percent of the value of the grain produced was fed to livestock, so that essentially all expenses are attributed to grain production.

Explanation of Table 1

Costs and returns are given by farm size in Table 1. Fertilizer costs include both annual and depreciable fertilizer. Lime is now about the only fertilizer which is depreciated. Building costs include both annual repairs and depreciation. Machinery costs are the sum of repairs, depreciation, gas and oil, machine hire, and machine rental. Labor includes both hired labor and the labor of the operator and family, but not that paid for with custom-hired machine work. Seed and crop expense consists mainly of the cost of seed, seed treatment, herbicides, insecticides, and crop insurance. Total cost includes all the foregoing, some other small items, and the interest on capital invested in the business, including land capital.

Interest charged on land capital was subtracted from total costs to get non-land costs. This was figured in 1976 as 5 percent of a "normal" land value. It might be argued that real estate taxes and building costs should also be subtracted to get non-land costs. However, in calculating non-land cost per bushel, all land was assumed to be in corn, meaning that fertilizer costs would be higher than they actually were where 40 to 50 percent of the land was in soybeans. Real estate taxes would approximately equal the cost of the additional fertilizer needed if all the land were in corn.

For the non-land cost per bushel of corn, it was assumed that the yield obtained for the corn actually produced would be the same if all the land were in corn. This may have resulted in a slight overestimation of yield, affecting the per bushel costs given in Table 1.

After costs, Table 1 includes the dollar value of farm production per man. This, of course, depends on prices, but in any one year it generally reflects the use of labor vs. capital and the general efficiency of labor use. Along with this is the number of months of labor put in by the operator, his family, and hired help.

Family and operator labor was charged into all records at $9,300 a year. No management cost is included in the table. Normally, the amount left after all expenses and land return are accounted for is referred to as management return.

Corn and soybean yields are given in the last two columns of the table. To obtain the gross return, you can multiply the yields by the prices obtained; by target prices or loan prices;

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Table 1. — Costs and Returns on 1,257 Illinois Grain Farms

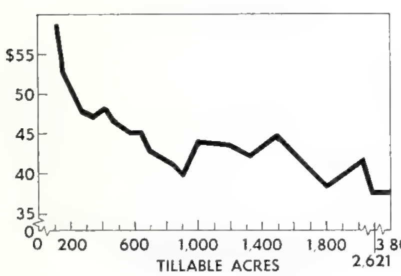
Total size of farm, acres	Tillable acres	No. of farms	Costs per acre: Fertilizer	Buildings	Labor	Machinery	Seed & crop	Total[a]	Non-land	Non-land cost/bu. corn	Returns per man	Mo. of labor/farm	Corn yield, bu.	Bean yield, bu.
80-160........	121	15	$31.82	$8.48	$41.75	$58.81	$26.06	$306.71	$218.94	$1.67	$ 82,716	6.6	131	31
160-240.......	188	97	30.57	9.08	38.68	53.23	25.74	296.86	209.49	1.60	92,425	9.5	131	36
240-320.......	262	134	30.31	7.76	33.29	47.65	22.17	273.89	188.92	1.46	93,302	11.3	130	38
320-400.......	340	167	30.36	7.14	29.15	47.00	24.45	270.86	184.91	1.36	103,419	12.9	136	39
400-480.......	435	188	29.92	6.84	26.81	48.36	22.75	269.35	183.74	1.35	112,439	14.6	136	40
480-560.......	489	160	30.91	6.50	24.85	46.49	24.46	267.35	181.75	1.30	128,891	15.9	140	39
560-640.......	569	135	33.82	6.31	23.69	45.44	24.16	264.22	179.22	1.32	132,189	18.0	136	40
640-720.......	643	96	34.56	6.74	23.16	45.37	24.76	267.49	181.82	1.30	135,997	19.4	140	41
720-800.......	708	80	33.19	5.47	22.59	42.76	23.71	259.29	173.97	1.26	135,010	21.3	138	41
800-880.......	779	62	31.62	5.28	22.92	42.15	24.87	257.07	171.32	1.23	137,786	23.8	140	39
880-960.......	869	38	34.06	4.82	22.19	41.08	23.50	255.84	170.68	1.22	148,082	24.6	139	42
960-1,040.....	917	20	35.32	5.23	21.04	39.89	19.04	252.35	162.30	1.21	146,037	26.23	134	42
1,040-1,120....	1,010	15	34.07	5.14	22.42	44.05	24.52	259.51	173.54	1.24	153,337	27.9	141	43
1,120-1,200....	1,074	15	31.49	5.45	20.66	43.92	25.14	250.31	167.65	1.28	143,202	36.5	131	41
1,200-1,360....	1,191	9	37.20	4.44	20.20	43.63	26.99	263.58	177.42	1.30	169,901	29.8	137	37
1,360-1,520....	1,334	8	29.70	7.26	15.60	42.27	23.31	244.72	159.53	1.10	219,234	29.6	144	43
1,520-1,680....	1,505	7	30.69	4.72	22.62	44.72	22.64	246.34	169.13	1.25	139,184	42.8	137	42
1,680-1,920....	1,819	3	36.71	3.71	22.81	38.55	27.27	255.67	172.24	1.19	161,732	56.0	145	40
1,920-2,320....	2,056	3	23.89	4.04	21.53	41.70	16.95	240.42	156.37	1.21	131,417	58.5	129	42
2,320-2,960....	2,621	3	35.41	5.22	23.15	37.85	24.19	250.05	161.88	1.48	101,250	76.0	109	38
2,960-4,000....	3,801	2	27.91	7.12	16.32	37.25	15.55	216.82	136.27	1.20	201,221	65.0	113	34

[a] Total costs include the preceding items, interest on capital invested in the business, and several other small items.

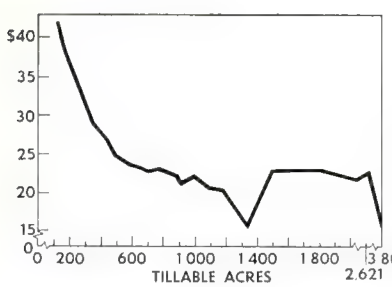
or by the price you expect for planning purposes.

Costs per acre

As would be expected, machinery costs per acre are high on the small farms (Fig. 1). The costs then decline rapidly, reaching a low point at about 900 acres. This is followed by a rise in cost and another low point at 1,800 acres, then still another rise and decline. The first low point at 900 acres represents the acreage where a set of machinery would be used at or near full capacity. To farm more acres, a farmer has to get more machinery, accounting for the subsequent rise in costs. The next low point is reached when the second set of machinery is fully used, and so on.

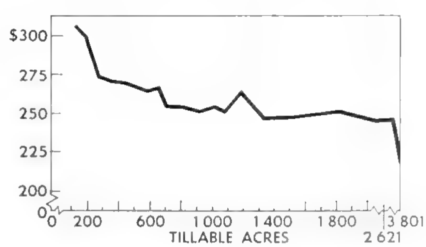


Machinery costs per acre. (Fig. 1)



Labor costs per acre. (Fig. 2)

Labor costs reach a minimum of $15.60 per acre at the average farm size of 1,334 tillable acres and dip again to $16.32 at 3,800 acres (Fig. 2). Except for these two dips, the labor cost graph would be relatively flat, though somewhat erratic, from about 450 acres on out. The slightly more erratic fluctuations for labor costs than for machinery costs may be partly due to a trade-off between labor costs and machinery investment, particularly where machinery is not being used at full capacity.



Total costs per acre. (Fig. 3)

Total cost per acre starts out at a high of just over $300 on small farms and drops fairly rapidly to between $250 and $260 for most of the other farm sizes except the largest (Fig. 3). Non-land costs mostly range between $160 and $180 per acre, with a high of over $200 and a low of $136.

Costs per bushel

For those who are concerned about policies on target prices, loan prices, and set aside, I have calculated the cost per bushel by dividing non-land cost per acre by average yield. The result was a high of $1.67 on the smallest farms and a low of $1.10 to $1.20 on some of the larger farms. For most size groups, cost per bushel ranged from $1.20 to $1.40. Yields on most farms in 1976 were especially good; thus the average cost per bushel was somewhat lower than we would otherwise expect.

With the proposed corn target price and loan price at $2.00 per bushel, it would appear at first glance that a non-land cost of $1.20 to $1.40

Table 2. — Returns per Bushel and per Acre Above Non-Land Cost at Various Prices of Corn

Price per bushel	Returns per bushel[a]	Returns per acre[b]
$3.00	$1.70	$221.00
2.75	1.45	188.50
2.50	1.20	156.00
2.25	.95	123.50
2.00	.70	91.00
1.75	.45	58.50
1.50	.20	26.00

[a] Assuming $1.30 non-land cost per bushel.
[b] Assuming 130 bushels per acre.

Table 3. — Money Required per Year to Amortize Full Price of Land at 8 ½ Percent Interest for 35 Years

Price per acre	Money required	
	1 acre	80 acres
$4,000	$360	$28,800
3,500	315	25,200
3,000	270	21,600
2,500	225	18,000
2,000	180	14,400
1,500	135	10,800
1,000	90	7,200

per bushel would not result in any great hardship. However, for many tenants, as well as for some owner operators and many landlords who have high indebtedness on their land, total production costs will be above the target price for corn.

Returns needed to pay off land

Table 2 gives the returns per bushel and per acre for land as the residual claimant at different prices of corn, assuming non-land costs of $1.30 per bushel and a yield of 130 bushels. At the proposed loan price of $2.00, there would be 70 cents left per bushel, or $91 per acre.

For the past year or more, high-quality grain production land in central Illinois has been commonly selling at $3,500 to $4,000 per acre, and some small tracts have even brought more. Assuming that land indebtedness has been amortized over 35 years at 8½ percent interest, it would take a payment of $360 each year to pay for an acre of land bought at $4,000 (Table 3). If a farmer, having recently bought $4,000 land, gets only $91 residual per acre to pay for it, he obviously has to have considerable capital accumulated in previous years or at least three debt-free acres for each acre of newly purchased land.

Table 4 shows the number of acres from which income would be required to pay for one acre amortized at 8½ percent over 35 years for various combinations of land and corn prices. It assumes that yields and non-land costs for corn production remain stable. Under these conditions, a farmer who had one acre of land free and clear for each acre he bought, could afford to pay $4,000 an acre if he were assured that corn would be $2.75 per bushel. Many farmers do buy land whenever they have an acre to throw against each purchased acre. However, with continuing low corn prices, many farmers will be hard pressed to keep up the payments on recently bought land unless they had substantial cash to pay down.

Effects on land prices

At some elevators in central Illinois, corn has recently been below $1.60. While this is bound to put some downward pressure on land prices, they are not likely to fall dramatically, at least not very soon. Most recent purchases of land are well financed and held by farmers who either had or still have substantial cash reserves or very large operations from which to draw money for land payments. Land from estates and retirees will likely not be offered for sale if prices weaken substantially, so there will be a natural constriction of supply which will tend to support land prices for several years. However, we are not likely to see any more record high-priced sales until corn prices return to $2.50 and above.

People own land for many reasons other than the cash profits, so that the correlation between land prices and return from land is lower than we might expect. Most people buying land do so as a long-term investment, and if they believe that a downturn in returns is temporary, their decision to buy may not be affected.

Many farm families have a long tradition of owning land and will continue to do so as a repository for their savings. For some farm operators, owning land is part of guaranteeing themselves a job much as a laboring man pays union dues. These farmers will pay a higher price for land than the economic return would usually appear to justify.

Some land is bought by foreign investors who see the stability of our society and the tradition of individual land ownership as important in preserving their assets. Such people are not much concerned about the relative return from land or short-term fluctuations in commodity and land prices.

For all these reasons, land prices will probably not drop to 1972 levels, although they may drift downward if grain prices remain low.

Table 4. — Number of Acres of Land Required to Amortize One Acre[a] at Various Prices of Corn and Land

Price per acre of land	Price per bushel of corn						
	$3.00	$2.75	$2.50	$2.25	$2.00	$1.75	$1.50
	1-2 acres required		2-3 acres		More than 3 acres		
$4,000	1.63	1.91	2.31	2.93	3.96	6.15	13.85
3,500	1.43	1.67	2.02	2.56	3.46	5.38	12.12
3,000	1.22	1.43	1.73	2.20	2.97	4.62	10.38
2,500	1.02	1.19	1.44	1.83	2.47	3.85	8.65
	Less than 1 acre						
2,000	.81	.95	1.53	1.46	1.98	3.08	6.92
1,500	.61	.72	.86	1.10	1.48	2.31	5.19
1,000	.41	.48	.58	.73	.99	1.54	3.46

[a] If all returns above non-land costs are used for this purpose, assuming non-land cost at $1.30 per bushel and yield at 130 bushels per acre.

Pole-Building Anchorage Systems

JAMES O. CURTIS and DONALD E. FERGUSON

MANY FARMERS use pole or post-frame buildings for machinery storage and other purposes. As farms and farm machinery become larger, the size of pole buildings seems to increase, making the need for an adequate foundation ever more critical.

Various pole-building anchorage systems are in use, but little is known about the forces that they can resist. For this reason, settlement, overturning, and withdrawal tests were recently performed on several types of anchorage systems (Fig. 1).

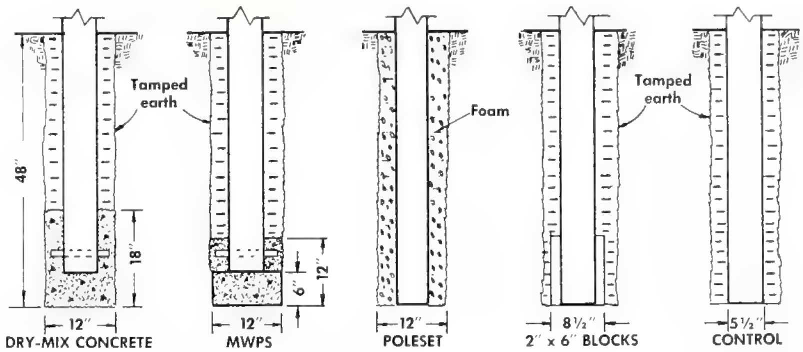
For all tests a nominal 6 x 6-inch pole (actual size, 5½ x 5½ inches) was placed in a hole 12 inches in diameter and 48 inches deep. In the **dry-mix concrete** method, one 90-pound bag of dry-mix concrete was placed under and around the base of the pole. An anchorage rod 11 inches long and ¾ inch in diameter was placed through the pole 3 inches from the lower end.

The **MWPS** (Midwest Plan Service) method consisted of setting the base of the pole on a precast concrete pad 11 inches in diameter and 6 inches thick; placing a rod as described above through the lower end of the pole; and adding 6 inches of concrete around the base of the pole.

The **poleset** method involved backfilling the entire hole with a polyurethane foam formed by two compounds mixed together. In the **2 x 6 block** method, 1-foot pieces of 2 x 6-inch material were nailed to each side of the lower portion of the pole. The **control** merely involved backfilling around the pole with tamped soil.

The study was done at the Agricultural Engineering Research Farm, on a site consisting of three soil layers: a hard, dry fill stratum (at the surface), the original black topsoil, and a yellowish-brown clay.

Two replications of each system were loaded to failure in settlement, withdrawal, and overturning. Results are summarized in Table 1.



Types of pole anchorage systems tested. (Fig. 1)

Table 1. — Results of Withdrawal, Overturning, and Settlement Tests

Item measured	Poleset	Dry-mix concrete	MWPS	2 x 6″ block	Control
Withdrawal loads and deformation					
Av. load at 1″ of uplift, lb.	8,850	4,463	3,500	563	242
Av. ultimate load, lb.	9,075	5,800	7,025	1,800	280
Av. vertical uplift at ultimate, in.	1.6	4.5	3.8	5.3	4.8
Av. horizontal force at 1″ of deflection, lb.	1,375	450	638	280	253
Load at a settlement of 0.08 ft., lb.[a]	6,319	5,297	3,012	2,590	1,586
Time of settlement, days	64	55	28	22	15
Factor of safety against each type of load					
Settlement	1.63	1.47	0.78	0.70	0.53
Overturning	1.03	0.34	0.48	0.21	0.19
Uplift	4.65	2.97	3.60	0.92	0.14

[a] Interpolated between loading increments.

A typical Midwestern pole building 12 feet high and 48 feet wide, with its trusses spaced 8 feet on center, has the following approximate design loads per pole: withdrawal — 2,000 pounds; settlement — 3,850 pounds; overturning — 6,000 foot pounds. These values were divided into the average experimental loads to obtain the factors of safety shown in Table 1. (A reasonable factor of safety would be 1.5 to 2.0.)

On the basis of our results, we reached these conclusions:

1. The poleset and dry-mix concrete systems have adequate strength against uplift and settlement forces.

2. The MWPS system is adequate against uplift forces. However, effective resistance against settlement forces requires either a cast-in-place concrete pad or firm soil under a precast concrete pad.

3. The 2 x 6-inch block system is not recommended for heavily loaded poles. It might be used where the load is a little more than just the pole itself can support.

4. The lateral resistance of all systems was inadequate. Additional lateral loading tests are needed.

Excluding labor, approximate costs were: 2 x 6 block, $2.04; MWPS, $2.50; dry-mix concrete, $2.50; poleset, $27.00. Cost of the poleset system may be reduced to $13 if material is bought in large quantities. However, this system would still be considered too expensive for most structures even though it showed the greatest strength.

James O. Curtis is professor of agricultural engineering; Donald E. Ferguson is research engineer, Morton Buildings Inc., Morton, Ill.

Tissue Culture May Revolutionize The Production of Peach Shoots

R. M. SKIRVIN and M. C. CHU

TISSUE CULTURE is a system whereby cells from very small pieces of plants are proliferated on an artificial medium under sterile conditions. Typical sources of plant tissue cultures include embryos, seeds, stems, leaves, shoot tips, root tips, callus (wound tissue), single cells, and pollen grains. For research purposes a tissue may be induced to remain unorganized indefinitely (as in callus); or to develop roots, shoots, and intact plants.

Scientists are interested in tissue culture for three reasons:

Rapid propagation. For some plants, propagation through normal procedures is either difficult or very slow. With tissue culture, however, propagation can be very rapid. For example, with conventional culture a single strawberry plant will produce at most about 35 runner plants in a growing season; with tissue culture, a single plant can theoretically produce several million plants in a year.

Elimination of disease. If a shoot tip (growing point) is used as the original explant, the resulting plants can be completely or essentially disease-free. Since many horticultural crops are perennial and are grown in constant exposure to soil- and insect-borne diseases, they are sure to be disease-infected. The elimination of disease organisms can thus increase the yield potential of many varieties. (As plants are reinfected in the soil, they can be replaced at intervals with disease-free stock.)

Improvement of asexually propagated varieties. Many horticultural cultivars are propagated by cuttings rather than by seeds because the plants derived from seeds are not "true" or identical to the parental clone. For instance, if one plants seeds from Red Delicious apple, one will probably never find an offspring that is identical in all respects to the parent. However, with the normal cutting and grafting procedures used to propagate apples, an individual will rarely vary from its parent. When variation does occur — a mutation of fruit color being the most common — the variant plant can be introduced to the market as an improved strain. Plants produced from tissue culture of many asexually propagated crops have been identical to the parental variety except for a small percentage that are similar but not identical. The differences are usually minor, but may benefit varietal improvement programs. Typical changes have been in leaf shape, fruit color, disease resistance, and growth habit.

R. M. Skirvin is assistant professor of horticulture; M. C. Chu is assistant horticulturist.

Procedure

When a plant part is excised from a living plant, it usually contains bacteria or fungal spores which will grow very rapidly on the medium intended for the culture of the plant cells. Consequently the first step in preparing a plant part for tissue culture is to eliminate the microorganisms by sterilization. The tissue piece is then explanted onto a previously prepared culture medium that contains all compounds (minerals, sugars, hormones, vitamins, etc.) which have been previously supplied by the parent plant. The explanted part is then grown in such a way that it can not be recontaminated.

The culture medium may be either solid agar or a liquid nutrient solution. When grown on agar, tissue usually forms a callus, while liquid cultures tend to produce single cells. On either medium, cells may be maintained as a callus or induced to form roots or shoots by changing the mix of hormones in the medium. In general, roots are stimulated by auxins (such as α-naphthaleneacetic acid) and shoots by cytokinins (for example, 6-benzylaminopurine). However, a combination of cytokinins and auxins is usually necessary to produce shoots in quantity.

Woody plants ignored

Most early tissue culture investigations concentrated on herbaceous species because they tend to yield uncontaminated cultures which generate plantlets with relative ease. Among the species that have been successfully cultured are tobacco, carrot, orchid, and tomato.

In general, woody plants have been ignored because they are much more difficult to propagate through tissue culture. There have been two major problems: It is difficult to obtain uncontaminated cultures from mature plants, even after disinfection. And many woody plants seem to lack the ability to produce roots and shoots from callus.

Only recently have investigators seriously attacked the strenuous task of developing intact plants from tissue pieces of woody plants. Success has been reported with eucalyptus, certain types of *Citrus*, poplar, hazelnut, Koa, and almond. The almond belongs to the rose family, which includes many of our most important fruit crops. The tissue culture of various members of this family has been receiving considerable attention in the past few years, so it seemed reasonable to expect that the peach, a rose-family member, should grow well in tissue culture.

At left, an explant of Redhaven peach developing new shoots at the axils in the culture tube. At right, same explant after removal from tube. (Fig. 1)

Production of peach shoots

Rapidly growing shoot tips were taken from Redhaven peach in the early spring. After being disinfected with 10 percent Clorox, the tissues were explanted onto Murashige and Skoog medium, which contained ascorbic acid (50 milligrams per liter) and the hormones 6-benzylaminopurine (2 milligrams per liter) and α-naphthaleneacetic acid (0.1 milligram per liter). After a week the dead and contaminated cultures were thrown away and the remaining cultures were grown in continuous light at about 25°C. (77°F.).

Within 6 weeks the leaves on some of the cultures began to expand and turn green and soon new shoots began to appear in the axils, or the region where the leaf petiole attaches to the stem (Fig. 1). These axillary shoots continued to grow and soon filled the culture tubes. Each shoot was explanted onto fresh medium and each in turn produced more shoots.

At present one shoot tip can produce six shoots in about 3 weeks on our medium. With every new shoot producing six more shoots, hundreds of millions of new shoots could be produced from one shoot tip in a single year.

Possibilities

Since the peach shoots produced in our laboratory were developed from the growing point of the parental plant, some of them may be disease-free. However, the disease status of these shoots can only be determined by further studies.

The phenomenal number of shoots which can be produced in this manner will have economic importance only when the young shoots develop root systems. Experiments are therefore under way to determine whether it is more feasible to root the shoots or to graft them onto rootstocks in the laboratory. The rooted shoots will be planted in the field and examined for any variation in fruit quality, disease resistance, growth habits, and other appropriate characters in an effort to select improved forms of the Redhaven peach.

The tissue culture procedures outlined above will be significant for three reasons: (1) The production of rooted or grafted peach varieties in such large numbers promises that disease-free varieties can be made available throughout the world. (2) Once a disease-free variety is obtained, it can apparently be maintained indefinitely in tissue culture by repeated sub-culturing. (3) This is the first report of successful tissue culture of the woody perennial, peach.

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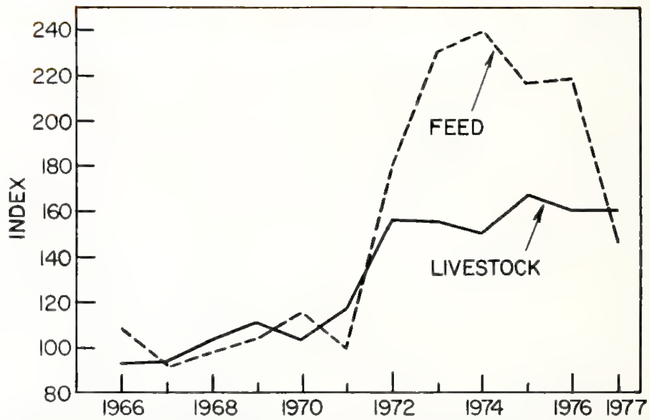
FARM BUSINESS TRENDS

From 1965 through 1972 changes in the overall price of livestock were generally paralleled by changes in feed prices (Fig. 1). In 1973, however, feed prices increased dramatically as a result of large exports of corn. With continued foreign demand and a small corn crop, feed prices went even higher in 1974. They remained relatively high in 1975, reflecting record exports of corn and the rebuilding of livestock numbers. The high prices of 1976 were due primarily to high-priced soybean meal. The record large corn crops of 1976 and 1977 have now caused feed prices to decline rapidly.

During the same 1973-1977 period, overall livestock prices remained fairly constant. Diverging livestock and feed prices significantly affected the profitability of livestock feeding in the 1970's, as indicated by the ratio of livestock prices and feed costs (Table 1). Since the major feed components are grains and protein supplements, the weighted average price of corn and soybean meal gives an approximation of feed costs and has been used for the calculations in the table.

Compared with 1966-1969, feeding profitability was high in 1971-72, but declined steadily through 1974-75, when it was only 63 percent as profitable as in 1966-1969. Profitability increased moderately in 1975-76 and 1976-77, but remained well below 1966-1969 levels. Because of recently declining feed prices, feeding profitability is now above the 1966-1969 level and is approaching the level of 1971-72.

The recent reversal in the profitability of livestock feeding has implications for the currently depressed feed grain market. Inventories of feed grains increased during the 1976-77 marketing year and a record large corn crop is now being harvested. To avoid a further build-up of corn stocks a year from now, feeding needs to increase by 18 percent. An increase of this magnitude is unlikely (the USDA projects an 8-percent increase). However, current feeding profitability ratios indicate that progress in this direction is certainly possible. — *D. L. Good, Extension Economist, Outlook and Sales Management*



Indexes of livestock and feed prices (1966-1969 = 100). Data are for crop years beginning October 1, except that 1977 figures are those available on October 15. (Fig. 1)

Table 1. — Livestock Prices, Feed Costs and Feeding Profitability

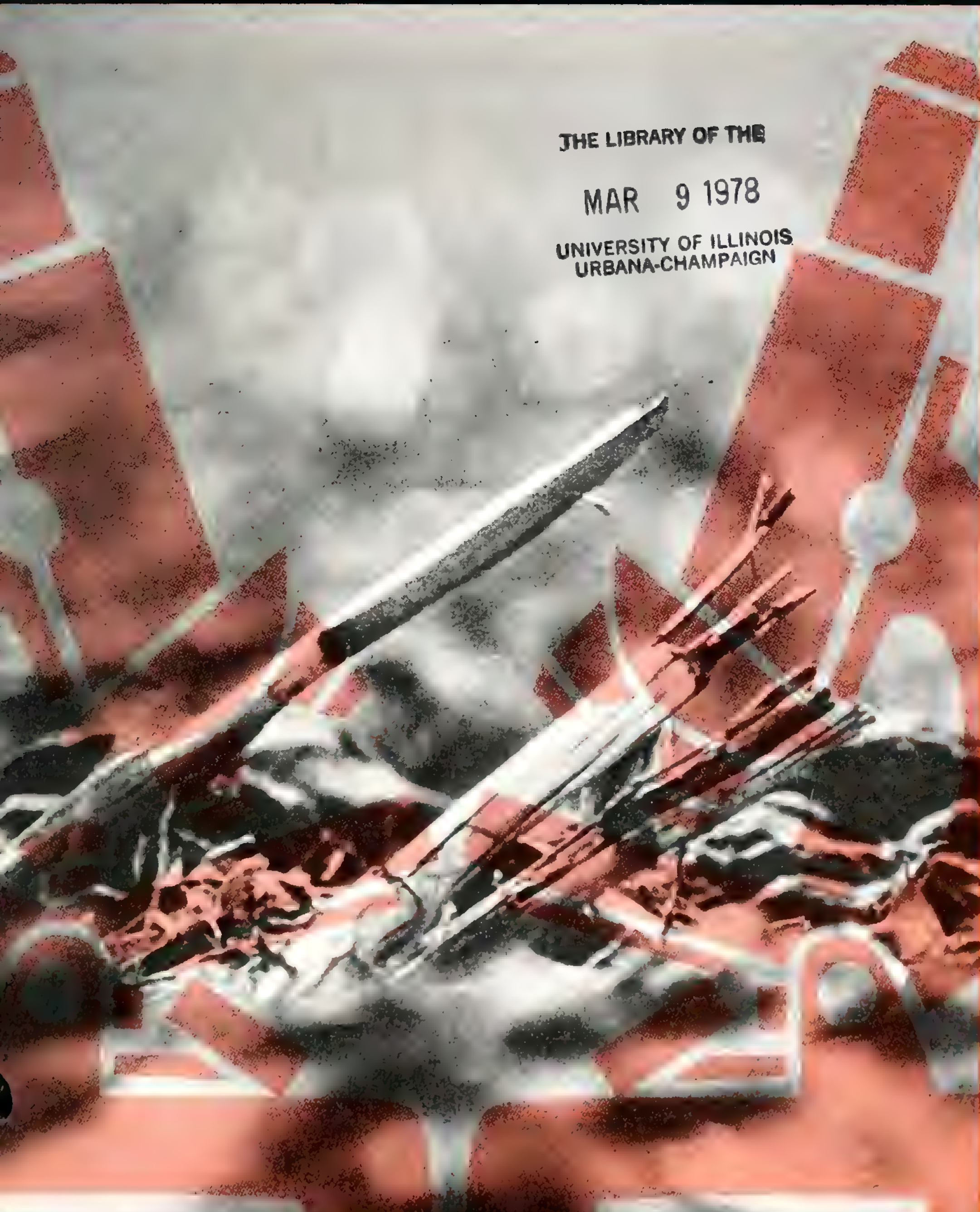
Year	Index of livestock prices[a]	Index of feed costs[a]	Profitability ratio
1966-67	92.9	107.1	.87
1967-68	93.5	91.0	1.03
1968-69	103.5	97.7	1.06
1969-70	110.4	104.2	1.06
1970-71	104.0	115.8	.90
1971-72	117.5	100.3	1.17
1972-73	157.3	179.0	.88
1973-74	156.3	230.4	.68
1974-75	150.4	240.4	.63
1975-76	167.0	217.5	.77
1976-77	160.6	218.8	.73
Oct. 15, 1977	161.0	146.0	1.10

[a] 1966-1969 = 100.

Winter, 1978

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station



IN THIS ISSUE

Is it better to leave cornstalks on the soil or to harvest them for energy? (See page 14.)

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ILLINOIS

Illinois Agricultural Experiment

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(Cover picture by Paul Hixson Maul)

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OD AND AGRICULTURE ACT

and Agriculture Act of 1977, the nger powers in coordinating state- research, extension, and teaching nonths it has become clear that the allenge laid down by the Secretary lead agency for agricultural science

k of agencies conducting federally was "not fully coordinated," and een partially successful in respond- fected by their research." Admitting gricultural research and extension in mmensurate with needs," the act iate new funds to more nearly meet

several areas of research, including nan nutrition, environmental prob- gement, water conservation, home , climate and weather modification, small farms, export markets, animal disease and health care, and new crops. This research responsibility will be placed not only on the USDA and the state agricultural experiment stations, but also on other colleges and universities and the private sector.

The act also requires that station directors and deans of the colleges of veterinary medicine "develop a comprehensive animal health and disease research program for the state. . . ." This program is to be submitted to the Secretary of Agriculture and will be used as the basis for fund allocation.

Grants for future research, including competitive grants, are to be administered by a new USDA agency, SEA (Science and Education Administration). Projects in each state will continue to require the approval of the state experiment station director.

We can but look on the grant opportunities and the surveillance implied in the coordination of research, extension, and teaching specified in the act as new challenges in maintaining a high order of excellence at the Illinois Agricultural Experiment Station. — *G. W. Salisbury*

The Evolution of a Public Agricultural and Food Policy

R. G. F. SPITZE

THE FOOD and Agriculture Act of 1977, adopted last September, signifies important developments not only for this country but for other nations as well. Some observers expect the act to fulfill their hopes for a national policy on food. Others maintain that it sets a new direction for farm policy. Yet the act clearly falls within an agricultural and food policy that has been evolving for more than a century.

Food and agriculture have been entwined in practice, if not as policy concept, from the dawn of civilization. As self-subsistence gave way to specialization, exchange, and markets, agriculture and food became interdependent. To suppose that commercial agricultural production proceeds without reference to food use is as close to fantasy as to suppose that food can be consumed without concern for its production.

A century and more ago, U.S. land grant and homestead programs reflected society's concern for its food supply. More recently, this concern has been expressed by governmental focus on food aid for the undernourished and on the stability, price, and purity of the food supply. Knowledge of the interdependencies of the total system has further integrated government decisions about the welfare of the farmer and the consumer.

The policy model

This evolution of an integrated public policy is not adequately captured by either the term "agriculture" or "food" alone. Hence, "agricultural and food policy" has emerged as a descriptive term and can be best understood within a system of concepts (Fig. 1).

R. G. F. Spitze is professor of agricultural economics.

Policy may be conceived as an identifiable decision and action in a problem situation to achieve a desired end, and encompasses most of what people and their institutions do. When policy arises from individuals and interest groups, it is *private policy*.

But not all problems of society are solved by private policy. Conflicts persist; community goals remain unattained; and individual actions can often affect society adversely. When policy emerges from many individuals and group interests through compromises under representative governments, it is *public policy*. A major responsibility of public agricultural research and educational institutions is the creation and dissemination of dependable knowledge to help citizens fashion their own policy.

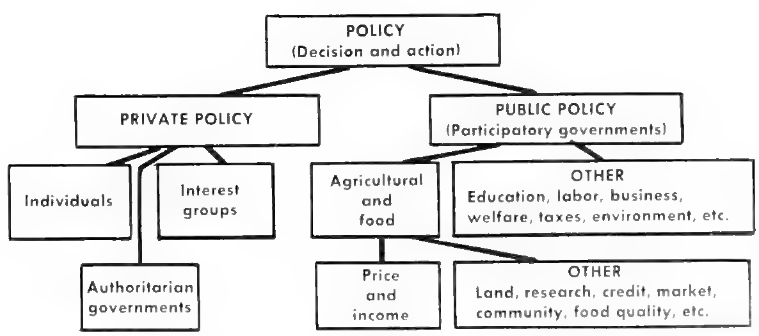
Public agricultural and food policy is evolving out of concerns first focused on the farm, later on the agricultural sector, and increasingly on food (Fig. 2). The concerns in the first century of our nation's history on developing a productive agriculture have been expanded in the past few decades to encompass consumer concerns about quality, availability, and costs of food.

Public price and income policy represents yet another evolution within agricultural and food policy. Early concerns about land and conservation, education and research, credit, and marketing gave way in the 1920's to concerns about prices, income, consumers, trade, and Treasury transfers. The 1977 act is primarily this type of policy even though it speaks to some of the other concerns.

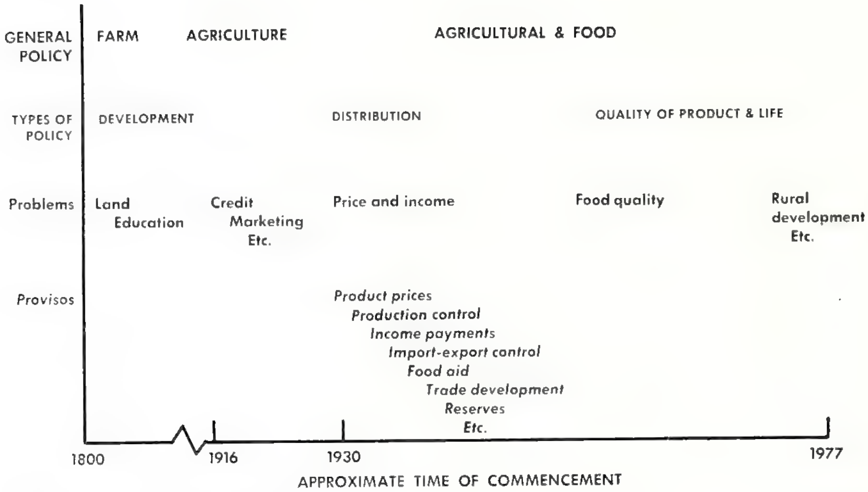
Reasons for continuing policy

In addition to the persistent price and income problems discussed earlier (ILLINOIS RESEARCH, Fall, 1977), other rationales have supported a continued public price and income policy.

Economic importance. The agricultural and food sector remains important economically in the presence of our increasingly urbanized, industrialized economy. It is true that, as proportions of total national aggregates, farm production dropped from 11 percent to 6 percent between 1950 and 1976; food and clothing consumption, from 39 percent to 28 percent; and farm population from 15 percent to 4 percent. Yet this sector essentially supplies the nation's population with raw food and produces a net agricultural export worth $10 billion to $12 billion a year. This is applied against a mounting nonagricultural trade deficit.



Classification of agricultural and food policy. (Fig. 1)



Evolution of U.S. agricultural and food price and income policy. (Fig. 2)

Productivity. Farm production continues to maintain a favorable record (Table 1). Aggregate farm output has increased between 10 and 13 percent over the five-year intervals since 1950 except in the 1960's, when 55 to 65 million acres of cropland (from a total of 350 million) were set aside annually to relieve excess supply. Output by our expanding nonfarm economy increased much faster than farm output, but farm productivity and farm worker productivity have continued consistently higher than nonfarm.

Processes and alternatives

The complex process of formulating public policy gained speed soon after the 1976 election. Proposals, positions, and results of studies were issued by numerous public and private groups. The alternatives commonly considered were: extending the 1973 act with its relatively small impact; dismantling essentially all public price and income policy; or expanding public involvement.

By the time the new 95th Congress was organized in early 1977, numerous bills were before both houses. After extensive hearings both on Capitol Hill and across the nation, the Senate adopted its version of the new policy (S. 275) on May 24, 1977. The House of Representatives adopted a bill (H.R. 7171) on July 28. The House bill provided for lower farm income support than the Senate bill, but both proposed higher expenditures than were considered feasible by the Administration.

After days of negotiation, a conference version was agreed to on August 5 and was approved by both houses of Congress in September. Cast in the middle ground, this final version embodied less assistance than originally sought by the Congress, but higher Treasury cost than desired by the President. It was truly a compromise. President Carter signed the act on September 29, to set the course of agricultural price and income policy for the next four years. (See ILLINOIS RESEARCH, Fall, 1977, for a summary of the act.)

Primary changes

Although the 1977 act is within the same evolutionary development as preceding legislation, it does encompass changes and speaks to a broader scope of problems.

Grain reserves. For the first time, public policy provides for a minimal continuing national reserve of grain, including 300 to 700 million bushels of wheat, with the discretion of three- to five-year loans jointly controlled by government and farmers.

Food stamp program. The cash purchase requirement for food stamps was eliminated and the work requirement was strengthened.

Target price escalation. As in existing policy, target prices for the covered crops during the final three years of the act will reflect changes in variable, machinery ownership, and general farm overhead costs. However, the cost changes reflect a moving two-year average instead of one-year average costs for each commodity, and no adjustment is necessary to reflect yield changes.

Soybean loan. For the first time, a loan is mandated for soybeans, but the level is discretionary with the Secretary. In the past he has held the entire authority.

Set-aside and allotment base. For the first time, planted acreage in the preceding or current year instead of in a historic period is used to determine allotments, set-aside compliance, and target price payments.

Export embargo. If the government suspends the export of any normal export commodity with a loan program, price supports must immediately be raised to 90 percent of parity.

Agricultural research and education. Considerably higher levels of federal funding are likely and administration of programs will become more centralized, as discussed by Dr. Salisbury on page 2.

Table 1. — Changes in U.S. Farm and Nonfarm Output and Productivity

Change measured	1950-1955	1955-1960	1960-1965	1965-1970	1970-1975
			percent change		
Output					
Farm	12.2	9.6	7.7	3.1	12.9
Private nonfarm business	21.2	11.9	28.1	16.0	9.9
Output per worker hour					
Farm	32.4	44.4	36.9	25.8	25.9
Private nonfarm business	11.8	9.7	19.2	7.8	6.0
Farm productivity (output per unit of input)	9.6	15.0	10.9	−1.0	11.9

Sources: USDA, *Changes in Farm Production and Efficiency*, ERS Statistical Bulletin No. 561, September, 1976. USGPO, *Economic Report of the President*, January, 1977.

Size and Composition Of Pots Affect Vegetable Transplants' Growth

JOSEPH S. VANDEMARK and WALTER E. SPLITTSTOESSER

Tomato at left was grown in a 6.4-centimeter clay pot; the smaller plant at right in a plastic pot of the same size. (Fig. 1)

The size of the vegetable transplants you grow or buy depends partly on the size and type of container. This is illustrated by results of a recent study in the Department of Horticulture.

Crops used in the study were tomato varieties Jet Star and C-28; cabbage variety Market Prize; and pepper variety Sweet Banana. The vegetables were seeded into clay and plastic pots 10 centimeters (4 inches) in diameter; and peat, clay, and plastic pots 6.4 centimeters (2.5 inches) in diameter.

Six replications were randomized and grown in the greenhouse in early spring. Pots were arranged to allow each plant top the same amount of growing space (232 square centimeters or 36 square inches). Plants also received equal amounts of sunlight and water.

After six weeks, when the plants would normally be transplanted into the garden, their height was measured. The plants were then cut off at ground level and weighed.

Pot size

All vegetables grown in 10-cm. pots were taller and weighed more than those grown in 6.4-cm. pots (Table 1). The smaller size of the plants grown in the smaller pots was due to the limited amounts of nutrients and soil volume available for root growth. Roots became pot-bound within the 6-week period. Plants in 6.4 cm. pots had less weight per unit length, indicating that they were elongated and less compact than plants grown in 10-cm. pots.

Pot composition

Vegetable plants grown in 6.4-cm. peat pots weighed significantly less at transplanting time than those grown in either plastic or clay pots of the same size. In addition, tomato plants were taller, indicating that they were spindly. Peat pots lose water rapidly, necessitating frequent watering. Each morning all plant containers were watered to field capacity. Plants grown in peat pots appeared deficient in water by the end of the day.

The growth of plants in clay and plastic pots depended upon the pot size and the plant being grown. Tomato plants grew better in 6.4-cm. clay pots than plastic ones (Fig. 1). Plants weighed more and were more compact. However, tomato plants grew significantly larger in 10-cm. plastic pots than clay pots, with the weight per unit of length being the same in both kinds.

Pepper plants produced the same weight in both clay and plastic 6.4-cm. pots but were more compact in clay pots. There was no significant difference in pepper plants grown in clay or plastic 10-cm. pots.

Cabbage plants grew equally well in clay and plastic 6.4-cm. pots. Clay 10-cm. pots produced better and larger cabbage plants than plastic pots of the same size.

Some recommendations

For best plant production and development, 10-cm. containers are recommended. Cabbage plants grow best in clay pots of that size, tomato plants in plastic pots, and pepper plants in either type. If 6.4-cm. pots are used, tomatoes and peppers should be planted in clay pots. Cabbage plants will grow equally well in clay and plastic 6.4-cm. pots.

Plants in clay pots need more frequent watering than those in plastic pots. Clay pots are porous and lose water through the sides, while plastic pots are not porous.

Table 1. — Growth of Vegetable Transplants in Various Containers

Container	Tomato (Jet Star)		Tomato (C-28)		Pepper (Sweet Banana)		Cabbage (Market Prize)	
	Ht., cm.	Wt., gm.	Ht., cm.	Wt., gm.	Ht., cm.	Wt., gm.	Ht., cm.	Wt., gm.
6.4 cm.								
Peat	32	26	21	20	20	9	6	24
Plastic	30	29	18	22	28	14	6	27
Clay	29	34	18	27	23	14	6	27
10 cm.								
Plastic	44	53	28	42	30	21	9	53
Clay	38	45	26	40	31	23	9	62

Joseph S. Vandemark and Walter E. Splittstoesser are both professors in the Department of Horticulture.

Farm Tenancy And Family Values in An Illinois Community

SONYA SALAMON

WITH the soaring prices of Illinois farmland, young farmers often have difficulty in acquiring land of their own, and most of them have to start as tenants.

National interest was focused on the plight of the young farmer when a farm-investment mutual fund was proposed in 1977 by a Chicago-based bank and a national stock brokerage firm. The sponsors asserted that the plan would benefit tenant farmers by providing rental land for those unable to buy their own. However, farm interests opposed the plan for various reasons and it was ultimately withdrawn.

The proposal raises several questions about Illinois tenant farmers. Are tenant families mobile enough to move where land becomes available? With land values remaining high in the foreseeable future, can tenants ever anticipate land ownership? Do landlords exclude starting farmers from access to land and thus keep them from getting established?

In an ongoing research project, we are investigating some of these issues. We are concentrating on the relationship between the farm family as a kinship unit and its activities as an economic or production unit in three east-central Illinois communities. Results from one community are reported here.

Sonya Salamon is assistant professor of family relationships. Research assistants Vicki Lockhart, Barbara J. Kestel, and Karen L. Salberg assisted in the project. Franklin J. Reiss, professor of land economics, participated as a consultant.

The community

We began our study in a highly integrated community of German-American farmers, many of whom trace their farm ownership to the original homesteaders. Farming as a way of life has always been much valued, and high proportions of successive generations have continued to farm in the area, which covers about 48 contiguous sections of land.

We spent many hours with a few selected families discussing genealogies, family histories, and family land transactions. We also observed some of the families in the course of their daily lives.

In addition, we conducted a survey of a larger number of families in 1977, mainly to obtain general information about farm organization and land tenure. For this survey, we checked all 116 households present on 100 randomly selected quarter sections. Of the 116 households, 88 met our criteria for inclusion in the survey: The farm operation was more than 10 acres; farm product sales exceeded $2,500; and the operator worked less than 150 days off the farm.

Among other questions, we asked how much land was owned and how much rented. If land was rented, we explored the nature of the landlord-tenant kinship and the characteristics of the leasing agreement.

Land tenure patterns

The proportions of farmers in the survey who were tenants, part owners, full owners, and landlords, together with their ages and the acreages farmed, are given in Table 1. Median ages, we found, increased with land ownership.

Part owners made up the largest group — 44 percent of the total. The proportion of owned land to rental acreage varied a great deal, but the average ratio was 110 acres owned to 308 rented.

Table 1. — Characteristics of Farmers (88 Households)

Operators	Median age	Pct. of sample	Av. acres farmed
Tenants	29	16	224
Part owners	47	44	373
Full owners	57	18	337
Landlords	65	22	200

The vast majority of the lease agreements between landlords and tenants were of the customary crop-share type (50/50 in this area of fine soils). Only one-fifth of the agreements were written. Farmers explained that if an agreement has to be written, little trust exists, and the tenant is therefore not the sort one would want. However, a more tangible explanation is that this type of arrangement is possible because tenants and landlords are kin.

Kinship and tenancy

Only three of the landlords who lived in the area rented to a tenant who was not kin. Of the operators who rented some or all of their land, only 11 percent rented exclusively from non-kin (professionals, retired farmers, widows, corporations). Another 19 percent rented from both kin and non-kin, and 70 percent rented entirely from kin (Table 2). Forty-five percent rented from just one relative, while 25 percent rented from as many as 10 relatives.

About three-quarters of those who rented from only one source rented from their parents; the others rented from siblings, grandparents, aunts, uncles, and cousins (Table 3).

What does the high incidence of parent-landlords indicate about the future of tenant farmers in this German-American community? First, after perhaps 20 years of farming, tenants will likely own at least some of the land they farm. That is, they are on the "tenure ladder." It is evidenced in this community by the large number of part-owner operators in the middle age bracket. These operators will probably become full owners, partly through transfer or inheritance.

Table 2. — Part Owners' and Tenant Operators' Land Sources (53 Cases)

Source	Kin only	Kin + non-kin	Non-kin only
		percent	
Single landlord (53%)	87	.	13
Multiple landlords (47%)	52	40	8
Composite of tenants	70	19	11

Table 3. — Kinship Ties in Rental Agreements of 72 Households (Landlords and Tenants)

Relationship	Single source (61%)	Multiple source (39%)
	percent	
Parent-child	77	57
Grandparent-grandchild	5	0
Sibling-sibling	11	18
Aunt/uncle-nephew	5	25
Cousin-cousin	2	0

Families in the area expressed a strong belief that equal shares of an estate should go to equal heirs. Children can thus anticipate at least a share of a parent's estate and can often rent the acreage of non-farmer siblings. More than 75 percent of the tenants in our sample are likely to become at least part owners through inheritance from parents.

Pros and cons of kinship tenancy

The preference for relatives as tenants is based as much on mutual benefits as financial considerations. A tenant who is a relative is aided by the land provided, but he holds a greater responsibility to his landlord than would an unrelated tenant. The addition of kinship obligations makes the landlord-tenant bond a multidimensional one. Elderly landlords look on renting land to younger relatives as "helping them out" and "keeping things in the family." Some landlords even divide up their holdings among several relatives. This also insures the integration of the landlord into several families both socially and economically.

A number of community practices can be attributed to this concept of rentals as aid to family members. Often tenants who are kin live rent-free on the farmstead. They are then expected to reciprocate with services such as minor repairs. The wide use of crop-share lease agreements reflects the willingness of both parties to share risks equally. In a good year both gain, and in a poor year the losses are spread between both. Grandchildren who want to go into farming may even be given a small acreage while still in high school so that they can get experience.

To rent from relatives is considered more secure than to rent from non-kin. Once an agreement is made, it is likely to be for the lifetime of the landlord and, because of the kinship bond, there is always some possibility of inheritance. Landlords who are not kin may sell their land with short notice and the tenant seldom has an opportunity to inherit the land or even to buy it.

Kinship tenancy may bring problems as well as advantages. For example, it is extremely difficult for a landlord to remove a tenant who is also a relative. The tenant may find it very complicated to juggle the desires of various landlords who all claim special treatment out of kinship. Decisions about the sequence of working tracts, choices of crops, storage, and marketing may be difficult when there are several landlords to please.

Family values and farming

The German-American community in this study may have more kinship-related rentals than do other areas. Certain values in the community appear to favor rentals to kin. All the families, for example, place great importance on family bonds, trust, and providing for the welfare and security of family members. These values determine some of the choices made about estates and length of farming careers.

A median age of 65 for landlords — with some as young as their early 50's — indicates a tendency for early retirement with rental of family holdings to children. However, "retirement" may be quite active. At first, it means gradual withdrawal from the fields, often after the younger farmer gets married.

During the next decade the young farmer gradually takes over ownership of machinery and more control of the business although the parent is still involved in decisions concerning seed, fertilizer, and marketing. When children are in their late 30's, retired parents, who are by then in their late 50's or early 60's, may begin to transfer some of their land.

This retirement process has hinged on the older generation's ability to support themselves on a small portion of their holdings while either sharing returns on the remaining portion or financing its transfer.

The older generation's retirement is motivated by the goal of helping and providing for the succession of the children to the enterprise. This goal explains the high percentage of operators renting at least partially from their parents, and the evidence that operators are progressing up the tenure ladder.

The preference for kin as tenants has implications for the position of a young operator. To assist him in becoming established, relatives will often help him acquire additional land. Thus it is to a tenant's advantage to remain in the area where kin are even when land is scarce. These tenants, therefore, are not a mobile population. Furthermore, they do not always remain tenants, despite high land values. Only one person over 50 in the sample owned no land.

Up to now, the strong goal of early retirement and transfer of management and ultimately land has assured the entrance of new operators into farming. If older farmers decide to hold on to land by utilizing custom work, will new operators continue to enter the system?

The rental of land from siblings has resulted from the value of equal shares to equal heirs. Will this practice lead to continued breakup of holdings into smaller and smaller parcels?

The obvious benefits of kinship rentals for both landlords and tenants suggest that landlords elsewhere may prefer kin as tenants. That is one of the things we hope to find out as we study other communities.

Intestinal Coccidiosis of Livestock

NORMAN D. LEVINE

Coccidiosis, a common diarrheal disease, attacks all farm animals. It is caused by protozoan parasites (microscopic one-celled animals) known as coccidia. Most species of coccidia live inside the cells of the intestinal tract, but a few live in other places such as the liver or kidney. About 1,500 species have been named, mostly from ruminants, rodents, rabbits, and birds. We have been studying them for quite a few years at the University of Illinois, and have named over 100 species ourselves.

Each animal species has its own species of coccidia. The coccidia of one animal species cannot be transmitted to another. Cattle have at least 13 species of coccidia, sheep 15, swine 11 for sure and perhaps 13, dogs 13, cats 14, man 4, chickens 8 or 9, turkeys 7. Horses have at least one, but it is uncommon. We know almost nothing about some of these species, and we need to learn more about all of them.

According to USDA estimates, in 1951-1960 coccidiosis caused an annual loss of $14,569 in cattle, $998,000 in lambs, $34,854,000 in chickens, $11,866,000 in turkeys, and $317,000 in chicken and turkey eggs. These figures would be considerably higher today. Until recently we didn't think that coccidia were very important in swine, but now we have had several outbreaks in Illinois, and we have had to revise our opinion.

Life cycles

The life cycles of the intestinal coccidia are similar. An example is that of *Eimeria tenella* (Fig. 2), which causes a bloody diarrhea in chickens. A microscopic thick-walled, resistant cyst known as an oocyst (Fig. 3) is passed in the droppings. It contains a single cell. In the presence of air and at ordinary temperatures, it develops by a process known as sporulation. The single cell divides repeatedly until the oocyst contains four smaller cysts (sporocysts), each containing two infective cells or sporozoites. This sporulation process takes a day or more, depending on the species and the temperature.

When a chicken eats the oocyst, the wall of the oocyst breaks, releasing the sporocysts, which in turn release the sporozoites. These sporozoites enter intestinal cells, round up, grow, and divide to form about 900 new cells or first-generation merozoites.

The merozoites break out of the host cell, enter new cells, and produce 22 to 350 second-generation merozoites. These also break out of their host cells and enter new ones. Some of them produce 4 to 30 third-generation merozoites, but most begin the final part of the life cycle. They develop into male and female cells, which unite, lay down a wall, and turn into oocysts which break out of their host cells and pass out in the droppings.

Theoretically, each oocyst could produce something over 2 million additional oocysts, but actually such factors as host age, immunity, and size of infecting dose limit this number to 8 to 400,000, depending on the circumstances. Some cattle and sheep coccidia have giant stages in the intestine containing hundreds of thousands of merozoites. They can be seen with the naked eye. These species can produce millions of oocysts for each oocyst eaten.

One characteristic of the life cycle is that the infection is self-limiting. Each species has a definite number of generations, after which oocysts are produced and the infection is over. Reinfection can take place, but a good deal of immunity has developed, and reinfections are not ordinarily heavy.

Symptoms and causes

Coccidiosis ordinarily occurs in young animals. It causes diarrhea and sometimes dysentery (bloody diarrhea). It slows the growth rate, decreases feed efficiency, and may kill the animals. However, the disease is self-limiting and most affected animals do not die. Typically, there is a wave of disease in the herd or flock, and the animals which recover are relatively immune so that they do not suffer any more.

Coccidiosis is a disease of modern farming methods and of crowding; it ordinarily causes no trouble in nature. Calves and lambs which roam the range are rarely affected, but they may come down with the disease when they are put into a feedlot. The same thing holds true for other animals. The severity of the disease depends on the number of oocysts that are eaten, and animals on range don't get enough to harm them.

Adult animals have ordinarily been infected when they were young and have developed a partial immunity. They may carry a small number of oocysts, and are an important source of infection for the young. Therefore keeping old and young animals together is a good way of causing coccidiosis (and heavy worm infections) in the young.

Treatment

Once coccidiosis has appeared in an animal, there is no effective treatment, although supportive drugs and those that act against secondary in-

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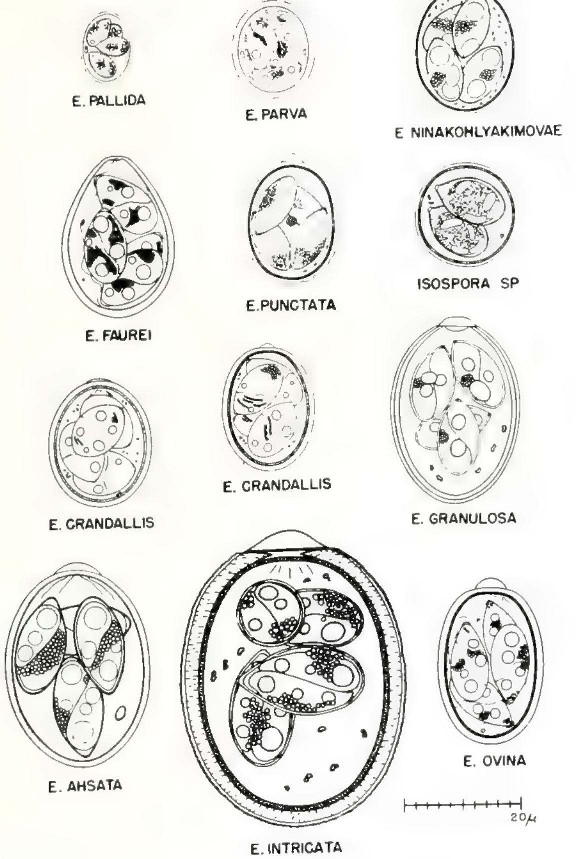
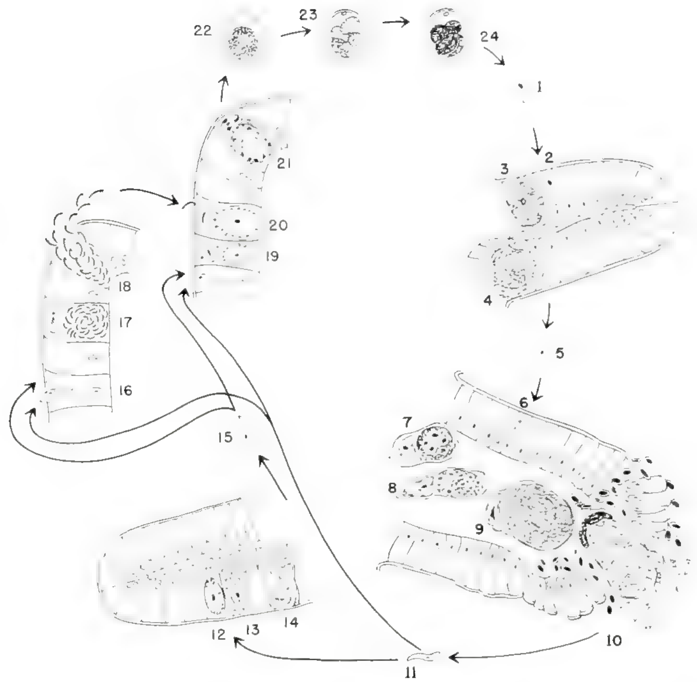


Oocysts of 12 species of *Eimeria* coccidia that infect sheep, magnified about 2,500 times. **(Fig. 1)**

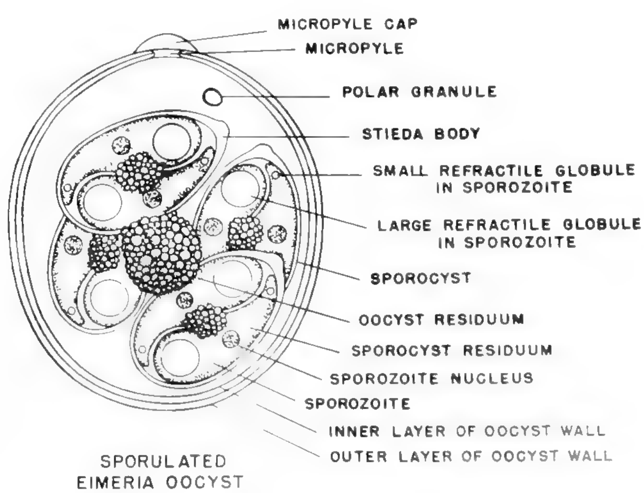


Life cycle of the chicken coccidium *Eimeria tenella.* An infective sporozoite (1) enters an intestinal cell (2) and produces first-generation merozoites (3, 4, 5), which enter new intestinal cells (6) and form second-generation merozoites (7, 8, 9, 10, 11). These either enter new intestinal cells (12) and form third-generation merozoites (13, 14, 15) or enter new intestinal cells and form male (16, 17, 18) or female (19, 20) cells which unite (21) and turn into oocysts (22). These pass out in the droppings and develop on the ground (23, 24) to form sporulated, infective oocysts containing four sporocysts, each with two sporozoites. The oocysts are eaten by a chicken to start the life cycle again. **(Fig. 2)**

fections are helpful. Many different drugs, however, are used as coccidiostats. What they do is prevent the disease from appearing at all. Sulfa drugs, arsenic derivatives, and several other chemical compounds have been found to have coccidiostatic effects. Practically every chicken-growing mash in the country contains a coccidiostat.

Unfortunately, coccidia develop resistance to coccidiostats more or less quickly, so there is a constant competition between the coccidia and the drug companies. New drugs have to be developed and produced before the coccidia develop resistance to the old ones.

One of these days we'll run out of new drugs and we'll have to depend on other methods to control coccidiosis. At present the best control method is sanitation. If young animals are raised in surroundings so clean that they can't pick up many coccidian oocysts and if they are separated from their parents as soon as possible, they will become immune without suffering disease. We are also going to have to develop additional control methods, and for this we need more knowledge about the coccidia themselves.



Structures of a sporulated oocyst of *Eimeria.* The oocyst contains four sporocysts, each with two infective sporozoites. The various structures are labeled. **(Fig. 3)**

Aspergillus flavus (near right) and Penicillium species growing on corn plated on a Czapeks-salt medium. *A. flavus* infected more than 60 percent of the kernels and produced enough aflatoxin to poison livestock.

Mycotoxins — Environmental Contaminants in Nature

R. E. FORD, B. J. JACOBSEN, and D. G. WHITE

WHILE MANY PEOPLE voice concern about man-made environmental contamination, relatively few recognize the potential hazards of naturally occurring contaminants, such as the mycotoxins.

Mycotoxins are chemical substances produced in grains, nuts, and other foods by fungi, the most common being species of *Aspergillus, Fusarium, Gibberella,* and *Penicillium.* Eating contaminated feeds or foods can cause disease (mycotoxicosis) in both animals and humans.

Mycotoxin problems are not new to Illinois or the Midwest. For example, more than 5,000 horses died of "moldy corn disease" in 1934, and many swine suffered from the feed-refusal and reproductive problems associated with the serious Gibberella ear rot problem of 1972. *Fusarium tricinctum* has been associated with cattle mycotoxicoses in Minnesota and Wisconsin and has surely caused problems elsewhere.

Often livestock producers complain of unsatisfactory performance, poor condition, and even deaths among their animals. These problems may be associated with mycotoxin poisoning due to consuming moldy feed.

The potential seriousness of the health hazard to humans is illustrated by a tragedy that occurred in the USSR in 1944. After eating millet contaminated by *Fusarium tricinctum,* more than 10 percent of the population in Orenburg and 50 other districts developed alimentary toxic aleukia, and many people died.

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Aflatoxin

The best known mycotoxin is aflatoxin, produced by *Aspergillus flavus* and other closely related species. *A. flavus* has for many years caused ear and kernel rots of corn in the southern states. This problem has resulted in efforts to shift production of white corn for human consumption to the Midwest from the South, since the aflatoxin risk is lower in the Midwest.

There are at least eight different compounds called aflatoxin. In general, they have caused more problems in feeds than in human foods.

A. flavus does not grow until the substrate has a moisture in equilibrium with a relative humidity of 85 percent. This is a minimum moisture requirement. Unlike many other fungi, *A. flavus* does not have a maximum substrate moisture content for growth; in fact, it grows faster at higher moisture contents. For starchy cereal grains such as corn, wheat, rice, and sorghum, moistures between 18 and 19 percent are in equilibrium with 85 percent relative humidity. The critical moisture content for soybeans is about 17 percent; for peanuts, 9 percent. The fungus produces aflatoxin between 12°C. and 42°C. with maximum production at 27°C. (80°F.). Thus aflatoxin is most likely to be produced in warm, humid climates.

While *A. flavus* flourishes on many crop plants, it does not produce equal amounts of aflatoxin on all of them. For example, the fungus produces much more aflatoxin on peanuts than on soybeans although it grows equally well on both crops.

Usually aflatoxin has been associated with storage decay, but it may occur in freshly harvested grain. Aflatoxin problems in new corn are consistently associated with previous drouth stress and with damage by birds and insects, particularly rice weevils, corn borers, and corn ear worms.

In 1977 low levels of aflatoxin were found in isolated lots of new corn in Illinois, Iowa, Missouri, and Indiana. Contamination was common in new crop corn in the Southeast, with some lots containing 2,000 parts per billion (ppb) of aflatoxin and many containing over 200 ppb. Levels above 200 ppb in fields are very hazardous for most animals.

Aflatoxin is one of the most potent known carcinogens. It also damages the liver. Unfortunately, man's sensitivity to aflatoxin is not known. However, cancer of the liver is most prevalent in countries where aflatoxin is most likely to be consumed. In Thailand, for example, consumption of aflatoxin-contaminated food was highly correlated with liver cancers.

Animals differ in their susceptibility. Listed in order of decreasing sensitivity are rats, young pigs, pregnant sows, calves, finishing hogs, mature cattle, and horses. Ducks and turkeys are the most sensitive amongst poultry.

While cattle are relatively insensitive to less than 300 ppb, 1 to 3 percent of the aflatoxin consumed may be excreted in milk. This amount is so small that it is unlikely anyone would ever consume significant quantities of aflatoxin in milk. Aflatoxins are not found in meat.

The U.S. Food and Drug Administration has an action level of 20 ppb for aflatoxin in foods or feeds shipped in interstate commerce. The tolerance for aflatoxin in milk is zero. While the FDA has no authority over grain shipped within a state, it has suggested that no more than 100 ppb

of aflatoxin be fed to animals and then only to mature, non-dairy animals.

Export grain should not have significant quantities of aflatoxin if foreign markets are to be maintained. Therefore the USDA is now routinely checking export grain for aflatoxin. Most large food and feed processing firms also regularly test for this substance.

Persons in the grain trade need to easily and quickly identify lots containing aflatoxins. The black (ultraviolet) light test developed at the USDA Northern Regional Research Laboratory detects a bright greenish-yellow fluorescent compound (BY-GF) produced by *A. flavus*. However, it does not detect the aflatoxin itself. For this, chemical tests such as the minicolumn test and thin layer chromatography are needed. Many laboratories in this and adjoining states will do these tests for a fee.

Aflatoxin contamination must be minimized to protect human and animal health. *A. flavus* invasion of grains and other foods can be prevented by controlling insects, both in the field and in storage, and drying grain to a moisture that will not allow growth of the fungus. Grain lots have been experimentally detoxified with the use of ammonia, sodium hydroxide, ozone, methylamine, and the bacterium *Flavobacterium aurantiacum*. None of these methods are approved at present.

Current research is under way to select corn lines for resistance to invasion by mycotoxin-producing fungi or to mycotoxin formation.

Other mycotoxins

In Illinois and the Midwest generally, the mycotoxins produced by *Fusarium* and *Gibberella* species are more common than aflatoxin. These mycotoxins include compounds known as the emetic factor, refusal factor, trichothecenes, and zearalenone.

The emetic and feed refusal factors are produced by *Gibberella zeae* (*Fusarium graminearum* syn. *F. roseum*), *Fusarium moniliforme*, and *F. nivale*. These factors cause animals, particularly swine, to vomit and refuse to eat infected grain. In fact, swine may starve to death before eating grain containing the refusal factor. This problem is common in corn produced in the northern Corn Belt and is most often associated with Gibberella ear rot.

Zearalenone (F-2 toxin) is produced by *G. zeae, F. tricinctum*, and *F. moniliformae*. These fungi also cause ear and kernel rots and are common throughout the Corn Belt. They can only grow in corn in the 23- to 40-percent moisture range and at temperatures of 3° to 30°C. Toxin production is favored by periods of lower temperatures and is often associated with delayed harvest.

An estrogenic compound, zearalenone is most active in nonruminant animals such as swine. It causes shrinking of the testes, swelling of the vulva with prolapse of the uterus in severe cases, enlarged mammary glands, and abortion. This mycotoxin may also retard growth.

The trichothecene toxins, including T-2, are produced by *F. tricinctum, F. equiseti, F. lateritium, G. zeae*, and *Trichoderma lignorum*. These fungi commonly attack grains and can grow at temperatures from slightly above freezing to about 30°C. T-2 toxin is produced over a range of 8°-25°C. with maximum production below 15°C.

T-2 and other trichothecene toxins have been involved in mycotoxicoses of poultry, swine, and cattle. Symptoms include severe inflammation of the gastrointestinal tract, hemorrhaging, edema, leukopenea, degeneration of the bone marrow, and death.

Like aflatoxin, the Fusarium and Gibberella toxins are heat-stable. Detoxification techniques for these toxins have not been established. Chemical analysis by thin layer chromatography is the only assay technique available. Grain containing these toxins can generally be fed if diluted with toxin-free corn.

The best way to reduce mycotoxin problems is to control the fungi that produce them. At present the use of disease-resistant corn hybrids seems to offer the greatest potential for control.

Table 1. — Mycotoxins and Toxin-Producing Fungi, Feeds or Foods Affected, and Effects on Animals

Toxin or syndrome	Fungal source	Feeds or foods affected	Effects on animals
Aspergillus toxins			
Aflatoxin; B_1, B_2, B_{2a}, G_1, G_2, G_{2a}, M_1, M_2	*Aspergillus flavus* and other members of *Aspergillus flavus-oryzae* group	Cereal grains, peanuts, oilseeds, and others	Liver damage, including cancer
Ochratoxins	*Aspergillus ochraceus, Penicillium viridicatum*	Cereal grains	Damage to liver and kidneys; abortion
Sterigmatocystin	*Aspergillus nidulans, A. versicolor*	Cereal grains	Liver damage, including cancer
Penicillium toxins			
Luteoskyrin	*Penicillium islandicum*	Rice	Liver damage, including cancer
Patulin	*Penicillium articae, P. claviformae*, others	Apple products	Edema, kidney damage
Fusarium toxins			
Emetic factor	*Gibberella zeae (Fusarium graminearum syn. F. roseum), F. moniliformae, F. nivale*	Corn, wheat	Vomiting
Feed refusal factor	Same as above	Corn, wheat	Feed refusal
Zearalenone (F-2)	*Gibberella zeae, Fusarium tricinctum, F. moniliformae*	Corn, wheat	Hyperestrogenism, poor growth, abortion
Trichothecenes	*Giberella zeae, Fusarium tricinctum, F. equiseti, F. lateritium, Trichoderma lignorum*	Cereal grains	Inflammation of gastro-intestinal tract, hemorrhagins, edema, leukopenia, degeneration of bone marrow, death

How Well Different Tillage Tools Incorporate Herbicide Into the Soil

L. E. BODE, B. J. BUTLER, and L. M. WAX

SEVERAL HERBICIDES must be incorporated into the soil for maximum effectiveness. Some of these, when applied on the soil surface, decompose in sunlight or are highly volatile; others are not activated without sufficient rainfall.

The effectiveness of many incorporated herbicides is influenced by the uniformity and depth of incorporation. How well various tillage tools mix the herbicide with the soil has already been the subject of various research studies.

Since these initial studies, however, new tillage tools have become available for incorporation, and existing implements such as the tandem disk harrow have been redesigned with larger blades at wider spacings. A study was therefore conducted in the Department of Agricultural Engineering to evaluate the soil incorporation characteristics of two sizes of tandem disk harrows, a Lely Roterra, and a Forrest City Do-All. The small tandem disk studied had 20-inch diameter blades spaced on 7½-inch centers, and the large disk had 22-inch diameter blades spaced 9 inches apart.

Determining incorporation

Several techniques have been used to determine the distribution patterns of incorporation implements. Usually a traceable material is substituted for the actual herbicide.

A technique developed at the University of Illinois utilizes attapulgus clay granules coated with fluorescent powder. A heavy application of the coated granules is applied to a smooth, well-tilled soil surface and is incorporated into the soil with the tool being tested. Vertical cross-sections of the soil are then photographed under ultraviolet light. By projecting the slide-mounted photographs, we can determine the horizontal and vertical distribution of the granules in the soil.

Tandem disks

With both sizes of disks, the depth to which granules were incorporated depended largely on travel speed and operating depth. As travel speed increased, granules were generally incorporated to a shallower depth (Table 1). For example, when the small disk was operated at 4 miles per hour, 24 percent of the granules were incorporated in the top 2 inches of the soil (as an average of the 3½- and 6-inch operating depths); at 6 mph, 36 percent were in the top 2 inches. The large disk, when operated at the 3½-inch depth, followed a similar though less pronounced pattern.

As expected, depth of incorporation increased with depth of operation. When the small disk was operated at 4 mph and a 3½-inch depth, 42 percent of the granules were incorporated to a depth of 3 inches or more. At an operating depth of 6 inches, the proportion of incorporated granules at or below 3 inches increased to 53 percent (Table 1).

In general, the peak concentration of granules was at one-half to two-thirds of the operating depth of the disks. Exceptions occurred when the large disk was operated at a shallow depth or slow speed. Under these conditions there wasn't enough soil contact with the disk blades to invert the soil or give much mixing.

Tillage pattern did not affect vertical distribution. One pass, two parallel passes, or two perpendicular passes gave about the same depth of incorporation.

Travel speed, operating depth, and tillage pattern all affected horizontal distribution. It generally improved with increases in speed and operating depth, as seen from the coefficient of variation (C.V.) values in Table 2. Perfect distribution would result in a C.V. value of zero; thus, the smaller the value, the more uniform the distribution.

Two parallel or perpendicular passes with a small tandem disk gave greater horizontal uniformity than one pass (Table 2). A single incorporation pass concentrated the dye tracer in areas where crops could be damaged, with little or no concentration where weed streaking could occur (Fig. 1). Areas of high concentration were about the same distance apart as the disk blades.

The large disk generally gave less uniform horizontal distribution than the small one (Table 2). Two passes improved uniformity with perpendicular passes being more efficient than parallel ones. Spacing of disk blades and depth of operation seem more important than blade diameter in determining the degree of soil mixing.

Do-All and Roterra

Operating depth had the most influence on vertical distribution of granules by the Do-All and Roterra (Table 1). Both tools placed the granules much more shallowly than the disks.

The Do-All always put the peak concentration of granules in the top 2 inches of soil. With removal of the ground-driven reel, more granules were placed in the first inch. Thus, the reel may slightly affect vertical incorporation in the top 2 inches.

Travel speed had less influence on

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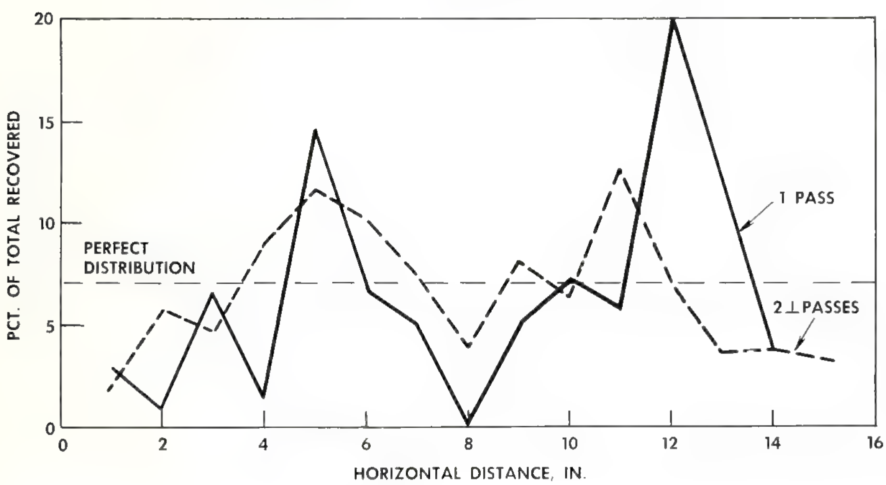
Table 1. — Vertical Placement of Granules in Soil When Incorporated With Four Implements

Incorporation treatment	Soil depth				
	0-1"	1-2"	2-3"	3 4"	4-5"
	percent of granules				
Small disk, 3½" deep					
4 mph	7.2	17.5	33.6	30.9	10.8
6 mph	10.7	27.9	29.8	25.2	6.4
Small disk, 6" deep					
4 mph	9.9	13.0	24.2	36.5	16.4
6 mph	12.1	22.2	32.0	21.5	12.2
Large disk, 3½" deep					
4 mph	26.1	25.0	27.2	15.6	6.1
6 mph	25.4	30.4	24.4	14.4	5.4
Large disk, 6" deep					
4 mph	23.0	29.8	26.0	15.0	6.2
6 mph	16.8	16.8	19.1	23.3	24.0
Do-All, 3" deep	32.1	37.4	21.0	5.9	2.6
Do-All, 5½" deep	28.2	25.7	23.7	14.4	8.0
Roterra, 3½" deep	24.7	34.2	22.0	14.1	5.0
Roterra, 5½" deep	16.4	27.3	31.4	17.1	7.8

[a] Average of 4 mph and 6 mph speeds. [b] Average of 4½ mph and 6½ mph speeds.



Horizontal distribution of granules incorporated in one and two passes with a disk having 7½-inch blade spacings, operated at 4 miles per hour, 3½ inches deep. (Fig. 1)

Table 2. — Horizontal Distribution With Four Implements

Incorporation treatment	C.V., pct.[a]
Small disk with 7½" blade spacing	
1 pass, 4 mph[b]	71.8
1 pass, 6 mph[b]	64.6
1 pass, 3½" deep[c]	70.0
1 pass, 6" deep[c]	66.4
2 parallel passes, 3½" deep[c]	58.8
2 perpendicular passes, 3½" deep[c]	59.5
2 perpendicular passes, 3½" & 6" deep[c]	50.9
Large disk with 9" blade spacing	
1 pass, 4 mph[b]	71.1
1 pass, 6 mph[b]	69.4
1 pass, 3½" deep[c]	68.4
1 pass, 6" deep[c]	72.2
2 parallel passes, 3½" deep[c]	72.8
2 perpendicular passes, 3½" deep[c]	61.0
2 perpendicular passes, 3½" & 6" deep[c]	60.3
Do-All	
4 mph, 3" deep	54.1
6 mph, 3" deep	62.7
4 mph, 5½" deep	85.0
6 mph, 5½" deep	82.7
5 mph, 3" deep, without reel	77.2
Roterra	
4½ mph, 3½" deep, rotor speed 265 rpm	57.2
6½ mph, 3½" deep, rotor speed 265 rpm	50.8
4½ mph, 3½" deep, rotor speed 333 rpm	40.8
6½ mph, 3½" deep, rotor speed 333 rpm	44.7
4½ mph, 5½" deep, rotor speed 333 rpm	57.3
6½ mph, 5½" deep, rotor speed 333 rpm	47.6

[a] C.V. = coefficient of variation. The smaller the value, the more even the distribution.
[b] Average of 3½" and 6" depths.
[c] Average of 4 mph and 6 mph speeds.

vertical incorporation by the Do-All than on incorporation by the disks. At speeds of 4 and 6 mph there was no significant difference in the percentage of granules incorporated in the top 2 inches. Tillage pattern is not a factor with the Do-All and Roterra, since only one pass is normally made to incorporate.

In tests with the Roterra, between 70 and 80 percent of the granules were incorporated in the top 3 inches of soil regardless of travel speed, operating depth, or rotor-tine speed. At an operating depth of 5½ inches, the peak concentration was at 2 to 3 inches. When operating depth was decreased to 3½ inches, peak concentration was at 1 to 2 inches.

Horizontal uniformity for the Do-All was affected by an interrelationship between travel speed and operating depth (Table 2). At an operating depth of 3 inches, horizontal uniformity decreased when travel speed was increased from 4 to 6 mph. Regardless of travel speed, uniformity also decreased when depth of operation was increased. Removing the reel reduced horizontal uniformity and increased the concentrations of granules in hot spots. Generally, the hot spots were spaced about as far apart as the cultivator sweeps.

With the Roterra, horizontal uniformity was influenced by travel speed, operating depth, and rotor-tine speed. In general, the most uniform distribution was achieved with a travel speed of 4½ mph, an operating depth of 3½ inches, and a rotor-tine speed of 333 rpm. A single incorporation pass with the Roterra provided the most uniform horizontal distribution of all the implements.

Summary

Two passes at the proper speed and depth with the disks can result in fairly uniform mixing of herbicides in the soil. Spacing of disk blades and depth of operation seem to be more important than blade diameter in determining the amount of soil mixing.

Under good soil conditions, a single pass with the Do-All or Roterra will give a uniform mixing of material in the top 2 inches.

Energy vs. Soil Productivity In the Use of Corn Residues

D. W. FRANZEN and L. F. WELCH

Society's growing concern about the exhaustibility of fossil fuels has spurred the search for new ways of utilizing the constantly renewable energy generated by the sun.

Agriculture is already in the business of capturing solar energy. Green plants store energy from the sun and convert it into food energy for people and animals. But much of the energy stored in crops is not utilized as food. For example, the only part of the corn crop that is normally harvested is the grain. Cobs and above-ground stover are usually returned to the soil.

These corn residues could be harvested and converted to such energy sources as methane. In 1975 the energy in unharvested residues on Illinois's 11 million acres of corn land equaled that in about 20 million tons of coal, or one-third of the coal mined in Illinois that year.

Although the 1975 corn residues were not used for energy, they were not completely wasted. Left on the land, they helped to minimize erosion, added organic matter, and returned nutrients to the soil.

If nutrients are removed from the field in harvested residues, they can be replaced by fertilizer. However, the overall effect of residue removal on long-term productivity of Illinois soils is not precisely known. To supply some of the needed information, we studied the effect of soil phosphorus (as measured by soil tests) and harvest date on the amount of corn stover and cobs produced and the nutrient content of these residues.

Experimental methods

The study was conducted in 1975 at Urbana. Corn had been grown on the experimental plots every year since 1967. From 1967 through 1970, annual phosphorus applications were 0, 40, 80, 120, and 160 pounds of P_2O_5 per acre. No phosphorus was applied after 1970. Residual phosphorus from the varying application rates in 1967-1970 resulted in different P_1 test values in 1975. All plots received adequate nitrogen and potassium.

Corn was harvested on three dates. Ear corn was hand-harvested and then all above-ground stover was harvested. Corn grain was shelled, and the grain and cobs were weighed separately. Grain, stover, and cobs were finely ground and analyzed for nitrogen, phosphorus, and potassium content.

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Yields

Use of corn residues for energy would depend on producing large amounts of non-grain without sacrificing grain yield. High levels of soil phosphorus would help to do this. In general, the higher the soil P_1 on the experimental plots, the greater the yields of grain, stover, and cobs (Table 1). The biggest increase was in grain yield. Thus, the proportion of the plant that was non-grain declined with increasing residual phosphorus, even though the absolute amounts of non-grain increased.

Grain yield was essentially the same at all three harvests. With machine harvesting, one would expect some loss of grain in the later harvests because of increased lodging and ear drop.

The proportion of non-grain was lower in the last two harvests than the early one. Although the yield of cobs did not change much, the yield of stover declined by about 1 ton. Most of this loss occurred between the first and second harvests.

If corn plants are left in the field for several weeks after they mature, the upper parts of the stalks may break off and wind and rain may cause some loss of leaves. These plant parts are not harvestable for energy, but they do return to the soil.

Nutrient removal

Nitrogen. The nitrogen content of grain increased as the residual phosphorus in the soil increased, but nitrogen in stover and cobs was not much affected (Table 2). Harvesting non-grain along with the grain on September 17 removed about 50 more pounds of nitrogen than would grain alone. Lesser amounts of nitrogen were removed in non-grain at the two later harvests because some of the stover became unharvestable after the first harvest. In the first harvest, the non-grain contained about 30

Table 1. — Yields of Corn Grain and Non-grain as Affected by P_1 Soil Test and Harvest Date

P_1 soil test, lb./A.	Grain, bu./A.[a]	Stover, lb./A.	Cobs, lb./A.	Non-grain as % of total
Harvested September 17				
4	120	5,901	1,273	55
8	160	6,391	1,402	50
10	165	5,958	1,252	47
13	171	6,301	1,374	48
20	182	6,729	1,426	48
Harvested October 24				
4	118	3,158	1,139	42
8	154	4,343	1,182	42
10	166	4,586	1,225	42
13	173	4,634	1,273	41
20	186	4,864	1,305	40
Harvested November 26				
4	123	3,572	1,105	44
8	160	4,253	1,235	41
10	164	4,476	1,254	42
13	177	4,155	1,248	38
20	183	4,858	1,274	40

[a] Grain yield is on the basis of 15.5 percent water. All other yields are on oven-dry basis. Grain is converted to oven-dry basis to calculate grain as percent of total yield.

Table 2. — Amounts of Nitrogen, Phosphorus, and Potassium in Corn Plant Parts as Affected by P_1 Soil Test and Harvest Date

P_1 soil test, lb./A.	Lb./A. in grain			Lb./A. in stover			Lb./A. in cobs			Nutrient in non-grain as pct. of total		
	N	P	K	N	P	K	N	P	K	N	P	K
Harvested September 17												
4	95	10	18	45	2.4	78	7.1	0.3	12	35	21	83
8	121	13	24	45	2.6	95	6.9	0.3	11	30	18	82
10	117	15	28	42	1.8	72	5.4	0.3	10	29	12	75
13	121	18	30	41	3.1	66	6.0	0.4	10	28	16	72
20	133	22	30	46	2.7	77	5.0	0.4	12	28	12	75
Harvested October 24												
4	96	10	19	24	0.9	38	6.4	0.3	13	24	11	73
8	114	16	27	34	1.3	49	6.9	0.2	12	26	9	69
10	126	17	29	33	1.4	47	6.6	0.2	10	24	9	66
13	127	19	29	33	1.9	46	5.6	0.3	11	23	11	66
20	137	23	33	34	1.9	51	6.4	0.3	11	23	9	65
Harvested November 26												
4	99	10	19	30	1.4	27	9.2	0.6	10	28	17	66
8	119	15	27	28	1.3	36	5.8	0.3	11	22	10	64
10	120	15	27	27	1.3	27	5.3	0.4	11	21	10	58
13	130	18	30	29	1.7	24	5.1	0.4	8	21	10	52
20	136	22	32	37	2.4	33	7.3	0.4	10	25	11	57

percent of the total nitrogen in the corn plant; in the last two harvests, about 24 percent.

Removing non-grain at the first harvest meant that 50 pounds of nitrogen would have to be replaced in the soil to sustain high crop yields. About 325,000 kilocalories of energy would be required to produce and transport this amount of nitrogen. However, about 43 times as much energy (14,750,000 kcal.) was contained in the 7,500 pounds of non-grain produced. Of course, some energy would be needed to harvest the non-grain, transport it, and convert it to a usable form.

If 7,500 pounds of non-grain are produced per acre, the energy in the non-grain produced on 5 acres is enough to heat an "average" three-bedroom home in central Illinois for a year.

Phosphorus. Grain grown on plots with the highest P_1 soil test removed about twice as much phosphorus as that grown on plots with the lowest test (Table 2). Soil phosphorus had less effect on the amount of phosphorus removed by stover and cobs.

On the average, non-grain contained only about 10 to 15 percent of the total phosphorus in the above-ground plant. About 3 pounds of phosphorus from fertilizer would supply the phosphorus removed if the residues were harvested.

Potassium. Much more nitrogen and phosphorus were present in the corn grain than in the vegetative portion. The opposite was true for potassium. At the first harvest almost 80 percent of the total potassium was in the non-grain (Table 2). This value decreased to about 68 percent at the second harvest and 60 percent at the third. Stover harvested November 26 contained less than half as much potassium as that harvested September 17. Harvest date did not affect the amounts of potassium in grain plus cobs.

Potassium in the non-grain decreased much more with late harvest than did nitrogen and phosphorus. This seems to be explained by the percent nutrient in plant parts at the different harvest dates. The percent nitrogen and phosphorus remained about the same in all plant parts for all harvests (Table 3). Percent potassium in grain and cobs was also unaffected by date of harvest. But the percent potassium in stover was drastically reduced as harvest was delayed.

Nitrogen and phosphorus are combined into organic compounds after absorption by plants. Potassium, however, remains in ionic form and may be washed out of plant material by water. Apparently rain between harvests washed out some of the potassium originally in the stover. This potassium was returned to the soil so it never left the field.

The large proportion of the total potassium in non-grain means that harvesting this fraction would greatly increase the amount of potassium fertilizer required for future crops. However, some of the potassium, nitrogen, and phosphorus in non-grain may be recovered and re-applied to soil after extracting the energy from non-grain.

The future

No one knows just how future energy needs will be met. Corn residues may be more valuable for some other use, or they may not be competitive with other energy sources.

Even if corn residues do prove competitive, research is needed to determine the effect of complete plant removal on future soil productivity. Removing organic matter from some soils may be disastrous because of increased soil erosion and compaction, and a decreased capacity of the soil to store water and nutrients. Other soils with nearly level topography and a high organic matter content may, however, show little adverse effect from non-grain removal.

Productive soil is as important as energy for future survival.

Table 3. — Percent Nutrients in Corn Plant Parts as Affected by Harvest Date[a]

Harvest date	Grain	Stover	Cob
Nitrogen, pct.			
Sept. 17	1.50	0.70	0.45
Oct. 24	1.54	0.74	0.52
Nov. 26	1.53	0.71	0.48
Phosphorus, pct.			
Sept. 17	0.19	0.04	0.03
Oct. 24	0.21	0.03	0.03
Nov. 26	0.20	0.04	0.03
Potassium, pct.			
Sept. 17	0.33	1.24	0.82
Oct. 24	0.35	1.08	0.93
Nov. 26	0.34	0.69	0.81

[a] Values are averaged over P_1 soil test levels.

Breeding Better Dairy Cattle

ANDREW J. LEE

Since one dairy bull can breed up to 40,000 cows a year, only a few are needed. Most bull calves from dairy herds are therefore raised for beef. Choosing which ones to keep is the most important step in breeding genetically superior dairy cattle.

Because bulls don't give milk, the performance records on a bull's female relatives are the primary basis for deciding whether to keep him for breeding. Records on his dam, his paternal half sisters, and his daughters are the most important ones. The objective is to choose bulls to father superior milking daughters in the next generation. So, while bulls are of the greatest importance, it is only because of the way their daughters perform.

Breeding programs that emphasize milk yield have been largely responsible for increased milk yields over the years. Another factor has been the feeding of fairly large amounts of cereal grains.

The importance of breeding in increasing milk yields is illustrated by a recent study of artificially bred cows in the Northeast. In 1957 average daily milk yield was 18 kilograms, feeding 50 people. In 1975 it was 23 kilograms, feeding 65 people. Further improvement is possible. For example, Beecher Arlinda Ellen, the product of several generations of breeding to highly selected bulls, produced a world record lactation of 68.5 kilograms a day in 1975.

Unanswered questions

Is even higher milk yield the most desirable goal? What about milk composition, growth of bulls for beef, and cow health? Will continued selection result in breeding cattle which do well on high grain diets but do poorly on high roughage diets? These are some of the questions we are trying to answer in our genetics research with dairy cattle.

We need to know the extent to which traits like milk yield and growth rate are correlated genetically. Another important question is whether these relationships change from one feeding or management system to another. Once these questions are answered, practical methods must be developed to use the knowledge for routine and accurate evaluation of dairy bulls for many traits. We also need to know the relative importance of different traits in determining long-term productivity of dairy cows.

Herd records used

Members of Illinois Dairy Herd Improvement Associations cooperated in one of our studies. The objective was to determine what feeding and management practices were useful for predicting differences between herds in milk yield. Questionnaires concerning certain practices were sent to owners of Holstein herds.

Only a few factors identifiable by questionnaire were correlated with high milk yields: (1) Supplementing pasture with silage, hay, or grain during the summer; (2) feeding less grain to heifers over one year of age, but feeding grain heavily (7 to 9 kilograms) during the two months before calving; (3) breeding heifers to calve at heavier weights. Region of the state, type of housing, and system of feeding were not important. Unfortunately the three important factors explained only 12 percent of the variation between herds in milk yield. Other factors, which we could not identify by questionnaire, accounted for over 80 percent of the variation.

Apparently herd average milk yield remains one of the best ways to identify herds with good feeding and management practices. The interactions of bulls with important feeding and management practices and with herds are being examined in continuing work.

Growth traits

When collection of the appropriate data from breeder herds is not practical, then experimental herds of dairy cows must be used for genetics research. This was done for a study of growth traits under different feeding levels.

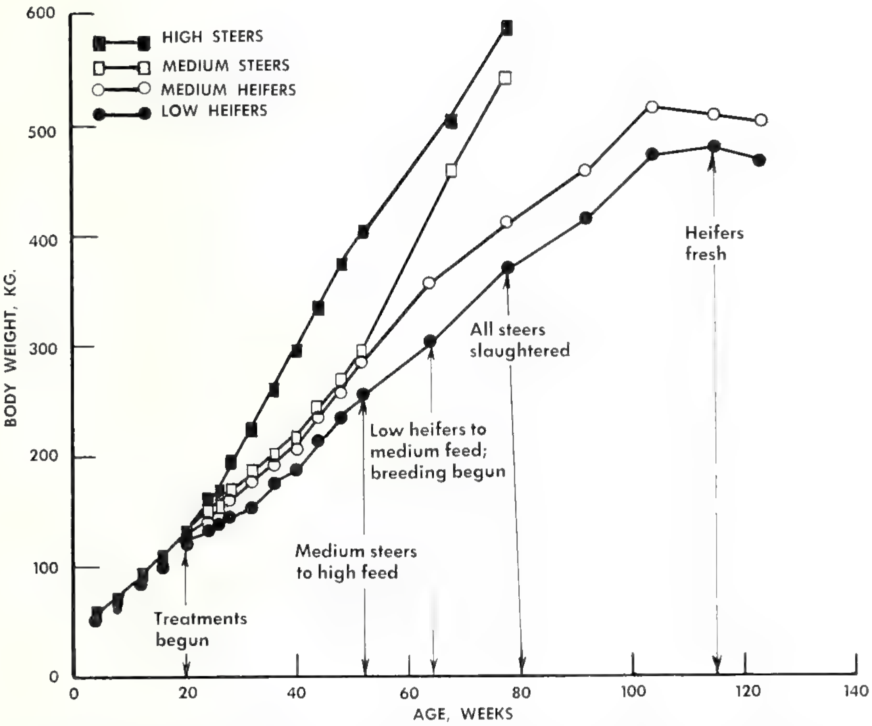
In this study, steers were fed at medium and at high levels and heifers at medium and low levels (Fig. 1). High-fed steers grew rapidly to an average weight of almost 600 kilograms by slaughter at 80 weeks. Medium-fed steers grew more slowly, but after they were switched to a high ration at one year of age, they grew faster than the steers that had been receiving the high diet all along. When slaughtered at 80 weeks, medium-fed steers were still lighter and smaller than the high-fed steers and their carcasses had slightly less fat and marbling. However, the two groups did not differ in meat quality as determined by physical measurements of the meat and taste panel evaluations.

Medium-fed heifers grew at about the same rate as medium-fed steers. Low-fed heifers grew quite a bit more slowly and were appreciably smaller than the medium-fed ones through 8 weeks of first lactation. However, low-fed heifers conceived at the same rate as medium-fed heifers when bred at 16 months, calved at the same age, and produced just as much milk.

According to these results, the feeding level during growth dramatically affects growth rate but not meat quality, milk yield, or reproductive performance. Growth rate, then, is likely to be the prime factor when evaluating a bull's progeny at different feeding levels.

It will be most interesting to examine differences between sires and

Andrew J. Lee is assistant professor of genetics, Department of Dairy Science.



Performance of steers fed at high and medium levels and heifers at medium and low levels. The high-level ration consisted of 3 pounds of hay per day, plus grain ad libitum. The medium level was that recommended by the National Research Council (NRC). The low level furnished about 85 percent of NRC energy requirements. (Fig. 1)

possible interactions between sire and feeding level, particularly in their effects on growth through 80 weeks.

The bulls used in the project have been commonly available through artificial insemination and have many daughters with lactation records. This will permit us to increase our knowledge about the genetic relationship between growth and lactation traits.

Evaluation methods

One of the most exciting results of our work is the simplified method that has been developed for accurately evaluating dairy bulls for several traits. Previous methods were practical for only a few bulls. Computers weren't big enough, fast enough, or cheap enough to perform a large amount of complex arithmetic for a large number of animals.

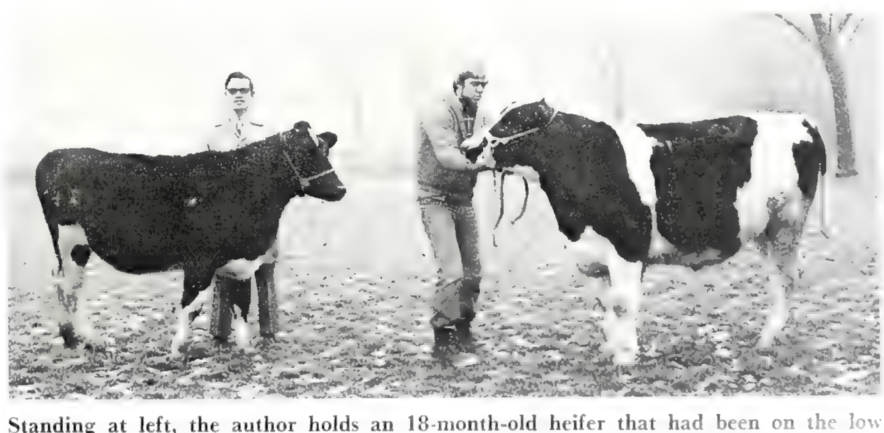
The simplified method depends on each cow having records for all traits. Under these circumstances it becomes practical to use the computer for evaluating a large number of bulls for several traits. Even related sires can be evaluated if the groups of interrelated bulls are not too large. A sire's interaction with the environment can also be evaluated. It is hoped that simplified methods can be developed for use even when some traits are unrecorded.

Mathematical simplifications of this type are obtained in a rather unusual way. Nothing more than pencils, paper, inspiration, and persistence is needed. Fancy equipment and chemicals are unnecessary. All you do is sit down and turn on the world's most powerful, portable computer (the human brain). Some time later out comes a huge basket of waste paper and a few pages of useful algebraic results. Of course to use these results in breeding better dairy cattle, we need to combine them with the records of real cows and the best of modern computers.

The problem in evaluating bulls for a combination of traits is choosing the right combination. Ideally, we would like to weight traits according to their importance for long-run productive efficiency. However, the proper weighting is difficult to determine and could differ from time to time and from one segment of the industry to another. A better knowledge of how different traits should be weighted is the primary objective of a North Central Regional cooperative project, in which Illinois is actively participating.

Fortunately, the combination of traits is easily changed in the simplified method of evaluation. In fact, most of the computer work can be done without knowing what traits are to be combined. Then, one or more combinations can be evaluated.

This research program involves a complex interaction between statistics, computers, and cows. With the right mix, it will provide new results helping to breed superior dairy cattle.



Standing at left, the author holds an 18-month-old heifer that had been on the low diet for 64 weeks, then on the medium diet. The steer at right, also 18 months old, had been fed the high ration continuously. (Fig. 2)

The Versatile Eastern Cottonwood

A. P. DREW and F. A. BAZZAZ

WHEN EARLY SETTLERS crossed the prairie, eastern cottonwood (*Populus deltoides* Bartr.) supplied them with fuelwood and construction material. Today, this versatile tree still fills many of our needs.

The species grows throughout Illinois. It is especially common along streams and river valleys, where moisture is abundant during the entire growing season. Growth is best on well-drained sandy loam or silt soils.

In northern Illinois, cottonwood is an early successional species on dunes along Lake Michigan. As one moves inland from the water's edge, it is often the first species to become established, preceding less sun-adapted species as pines and oaks on the nutrient-poor sand. On strip-mined soils in southern and western Illinois and Vermilion County, cottonwood is one of the first trees to seed in naturally on the cast overburden.

Eastern cottonwood grows rapidly. On good sites, young trees may grow 1.2 to 1.5 meters (or about 4 to 5 feet) a year. The species is one of the tallest east of the Rocky Mountains. Trees may eventually attain heights of 52 to 58 meters (170 to 190 feet) and diameters of 1.8 meters, or nearly 6 feet.

Commercial importance

Pulp from cottonwood is used to produce high-grade book and magazine paper. Cottonwood lumber is valued for making boxes and crates because it is lightweight and doesn't split easily. It is also used as core stock for furniture plywood.

This excellent specimen is about 5 feet in diameter and about 110 feet tall.

Commercial plantations have been established on the alluvial bottomlands of the Mississippi River in the southern states. With the long growing season and the rapid growth rate of the species, plantations in this area are managed on a 5- to 10-year rotation for pulp production. For lumber production, the rotation is 10 to 30 years.

Because of its quick growth even on marginal lands, cottonwood is currently being considered for intensive, short-term cultivation in biomass-for-fuel programs. It may be possible to capture energy from the sun through the rapid photosynthesis of this fast-growing hardwood and then, through a combustion process, reconvert the woody tissue to usable forms of energy.

Purpose of research

Experimental plantations were established at Urbana in 1970 by J. J. Jokela of the Department of Forestry. He obtained the seed from many stands along the Mississippi River as far north as Minnesota. Besides establishing stands at Urbana, he distributed seed to other investigators in the North Central states for provenance-progeny-clonal testing.

The local plantations, comprised of populations from a wide north-south geographical area, have been a valuable source of clonal material for our eco-physiological studies. We are attempting to define the nature and extent of ecotypic variations between populations of eastern cottonwood from different habitats.

Cottonwood is particularly adapted to the wet conditions of floodplains. Periodic inundation of its root system is an environmental feature to which the species has had to adjust during its evolution. Its rapid growth rate may be explained by high rates of photosynthesis, low rates of respiration, or by differences in the proportions of nutrient materials distributed to the leaves, stem, or roots. A variety of other adaptive mechanisms are also of interest, such as the effects of climatic differences on bud break, bud set, peak periods of shoot growth, leaf fall, and leaf structure.

Because eastern cottonwood is important commercially, it has been intensively investigated from the standpoint of breeding and tree improvement. Although we have not been involved in this type of work, we are interested in defining the basis for such efforts. This requires a knowledge of genetic variation, the ways in which it is expressed, and ultimately its effects on the growth of eastern cottonwood under different environmental conditions. It is then up to the forest geneticist to utilize the information by breeding hybrid races or superior progeny which reflect an inherent genetic advantage for rapid growth, better form, or desired pulping qualities.

In a less practical and more academic sense, we also wish to add to a growing pool of knowledge about plant ecology, a young and growing discipline. We are especially interested in the relationships of successional tree species with one another and with the environment. As part

of this study, we expect to explore the adaptive mechanisms of growth and physiology that a species develops to survive the pressures of encroaching species.

Studies of photosynthesis

Of fundamental importance is a plant's inherent ability to capture the sun's energy by chlorophyll and use it to photosynthesize or produce food from water and carbon dioxide. The photosynthetic potential of a plant is important to its ability to survive and grow under a variety of conditions.

We measured the rates of photosynthesis in cottonwood under different levels of light intensity and temperature. Optimum rates occurred at warm temperatures — 30°C. or 86°F. — and high light. Seedlings did poorly with low light as compared to more shade-tolerant species, suggesting that cottonwood is well-suited for growth as a pioneer on open floodplains with bright sunlight.

Artificial flooding of the root systems of cottonwood seedlings cut their rate of photosynthesis in half. After several weeks of flooding, however, seedlings almost completely recovered. Even when depressed by flooding, the rate of photosynthesis in cottonwood is still as high as the rates achieved by other tree species under normal conditions. Eastern cottonwood appears to be ideally adapted to bottomland areas where roots are periodically inundated.

Comparisons of populations

Our studies on photosynthesis led us into further work on the physiological responses of different cottonwood populations to conditions of the lowland habitat, especially temperature fluctuations. After the last frost of winter, there are many spring days in Illinois when nights approach freezing, or 0°C., but days are warm. Cottonwood from the cooler climates, in the northern part of the species' natural range, would be expected to have adapted to extreme diurnal temperature changes. On the other hand, planting stock from the south, where temperature fluctuates less widely, might find such conditions more limiting to growth.

Populations from Louisiana, Illinois, and Wisconsin were compared for their adaptation to temperature fluctuations. Greenhouse seedlings were exposed to near-freezing temperatures at night, then to light and high temperatures during the day.

There seemed to be no difference in the temperature at which maximum photosynthesis occurs. This was around 30°C. for all three populations examined. However, seedlings from a Louisiana population may require 2 to 4 hours for photosynthetic rates to reach maximum after nights at 4°C. Seedlings of northern Illinois origin take much less time and those from Wisconsin, less than half an hour.

Photosynthetic rates are related closely to size of the stomata. These very small slits in the epidermis of leaves and stems open during the day and close at night. By measuring the opening of the stomata after illumination, we found that changes in photosynthetic rate were reflected in the rate of stomatal opening as well. Plants of the Louisiana population were slower to open their stomata on mornings following cool nights than were those from more northern latitudes.

Seasonally, this type of temperature response does not appear to vary much. After investigating different populations during spring, summer, and fall, we found no observable differences in the extent of physiological response to cool nights. This suggests that other factors, such as daytime temperatures, timing of bud break, bud set, and leaf abscission are more important seasonal factors in determining growth.

For further comparisons between populations, we have used techniques of growth analysis. This has allowed us to examine the distribution of photosynthate to the leaves, stems, and roots. As a result, we have concluded that all populations do not respond the same in relative growth of different plant parts.

Seedlings of the Wisconsin population possess a peculiar type of adaptation which allows them to grow in height faster than either the Illinois or Louisiana populations. This is due not to the rate at which food is produced by individual leaves, but to the way in which food is allocated to different portions of the plant. Wisconsin seedlings produce thinner leaves and thus, for the same amount of food, greater numbers of leaves than the other populations. As photosynthesis is related more to the surface area exposed to light than to the mass of a leaf, these seedlings have a higher food-producing potential. The extra food is used to form more stem tissue to support the greater number of leaves, and so the seedlings grow taller.

This type of adaptation is of special interest to tree improvement people because it results in superior growth. However, the plantation work of J. J. Jokela, as well as that of others, shows that the initial height advantage gained by the Wisconsin population is lost in later years. Apparently other factors, such as climate, soils, pathogens, or branching habit and development of crown form, affect height growth in older trees.

Proposed new studies

Further work is necessary to determine the critical responses of different populations to combinations of day-night temperatures. How temperature can affect some populations more than others is of real interest to forest biologists, ecologists, and those concerned with factors that might limit the growth of cottonwood populations planted outside their natural habitat.

Other potential research might entail work on older seedlings that have already been studied to determine why one population might grow fast at first but be overtaken by other populations in later years.

Finally, collaboration among researchers from different areas is necessary to compare results of work done on similar populations.

A. P. Drew was formerly a research associate in forestry; F. A. Bazzaz is professor of botany and of forestry.

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FARM BUSINESS TRENDS

TRACTORS and some other farm machines have been declining in numbers since their peak during the 1960's. The 4.8 million tractors on farms in 1965 declined to 4.43 million in 1976 and to 4.4 million in 1977. Corn picker and corn head numbers dropped from 690 thousand in 1965 to 610 thousand in 1976 and 605 thousand in 1977. Combine numbers were 910 thousand in 1965 and 527 thousand in 1976 but increased to 535 thousand in 1977.

As the number of farms declined about 1.1 percent a year from 1970 to 1977, the number of machines per farm remained relatively constant: about 1.6 tractors, 0.20 combine, 0.22 corn picker or corn head, 0.24 baler, and 0.10 forage harvester.

Although the numbers of tractors and machines per farm have changed very little, the size of the equipment has greatly increased in recent years. Average size of tractors in 1965 was 37 horsepower; in 1977, 53 horsepower. New units sold increased in average size from 55 horsepower in 1965 to over 100 horsepower in 1976. Similarly, the size of combine with corn heads changed from two, three, and four row heads in 1965 to mostly four, six, and eight row heads in 1977. The increased machinery size is reflected in the 13-percent increase in machinery inputs from 1972 to 1977 (see chart).

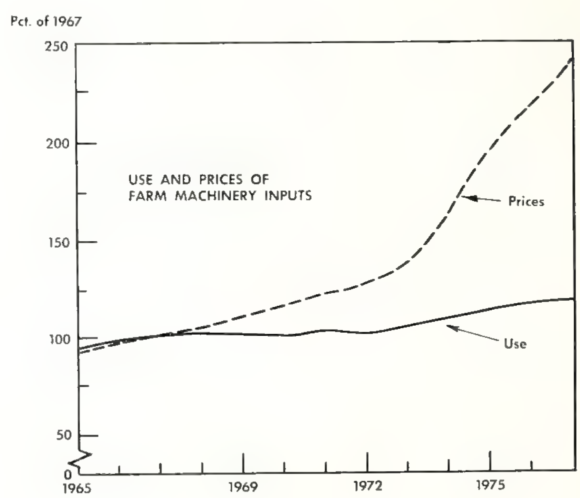
Diesel fuel has replaced gasoline as the fuel for tractors on farms. In 1950 about 10 percent of the wheel tractors manufactured were diesel tractors; in 1976, 91 percent.

Tractor sales were about 5 percent less in 1976 than in 1975. And for the first 8 months of 1977, they were about 3.5 percent below comparable 1976 figures. During these 8 months, sales of four-wheel drive tractors were off about 24 percent and two-wheel drive tractors of less than 100 horsepower were down 8 percent. However, the sales of two-wheel drive tractors over 100 horsepower increased about 8 percent. January-through-August sales of combines, corn heads, forage harvesters, mower conditioners, and manure spreaders were all down, ranging from 4 to 21 percent below last year's levels.

Prices paid for farm machinery increased 5 to 7 percent a year from 1967 to 1973. In 1974 prices increased about 18 percent; in 1975, 21 percent; in 1976, 11 percent; and in 1977, about 10 percent. Although machinery sales are off, prices for 1978 are expected to rise still further.

The increase in machinery size was only partly responsible for the higher prices. Since 1970, increases in labor and raw material costs to the manufacturer have raised tractor costs 63 percent per horsepower. Most of this increase was in 1976 (22 percent) and 1977 (10 percent).

In 1978 dealers in farm machinery are facing a difficult problem. Much of their equipment is already floor-planned and they will be under heavy pressure to move the equipment out of their lots. Many dealers will raise trade-in allowances and grant more favorable terms of payment. In general, dealers' margins can be expected to decline and if volume also falls some dealers may be in financial trouble. — *R. B. Schwart, Extension Economist-Farm Management*



Spring, 1978

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

IN THIS ISSUE

A new type of floor covering has been installed for rodeos and other events in the University's Livestock Pavilion (page 10).

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE Volume 20, Number 2

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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(Cover picture by Paul Hixson)

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CAMPBELL SUCCEEDS GARDNER AS ASSOCIATE DEAN

PROVIDING MAXIMUM SERVICE to students in the College of Agriculture and to the people of the state is the major goal of John R. Campbell, who became associate dean of the College and director of resident instruction on December 21. He succeeded Karl Gardner, who retired last August.

Before coming to Illinois, Dr. Campbell had been on the staff of the University of Missouri, Columbia, for 20 years and had previously done his undergraduate and graduate work there, specializing in dairy science. While at Missouri, he received numerous awards as an outstanding teacher and adviser of individual students and campus organizations. Among his other activities, he lectured widely on student-teacher relations; participated in numerous events sponsored by the University of Missouri extension division; and found time to continue his research.

He has written a book, *In Touch With Students,* which enunciates a philosophy for teachers, and is co-author of two textbooks: *The Science of Animals That Serve Man,* and *The Science of Providing Milk for Man.* He has also published many journal articles.

Dr. Gardner came to the University of Illinois in 1940 as an extension specialist in dairy science. After service as captain in the U.S. Army Medical Department during World War II, he returned to the campus in 1946 to teach and conduct research on dairy cattle nutrition.

He became associate dean and director of resident instruction in 1959. In that capacity, he dedicated himself to improving the quality of teaching in the College of Agriculture. A believer in a broad education, he encouraged students to supplement their agricultural studies with other courses and activities. His interest in education extended below the college level, and at meetings throughout the state, he urged that educational opportunities for elementary and secondary school students, particularly in rural areas, be improved.

During the past 20 years, he has accepted a number of overseas assignments, advising on nutritional problems and on agricultural education. He is now on a short-term assignment in Indonesia. — *G. W. Salisbury*

Controlling Leptospirosis of Cattle

D. N. TRIPATHY, L. E. HANSON, and M. E. MANSFIELD

Leptospirosis of cattle is an economic and public health problem in many areas of the world. In past years, it was recognized at the University of Illinois's Dixon Springs Agricultural Center, in the southern part of the state. But now the disease has been brought under control there, and in the process information has been generated that is a major contribution to control measures elsewhere.

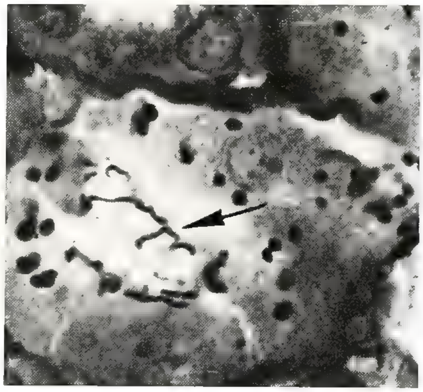
In the United States the disease has been caused by any one of six serotypes of *Leptospira*. These are *pomona, canicola, grippotyphosa, icterohemorrhagiae, hardjo,* and *szwajizak*. The first four have been isolated from several species of wild and domestic animals in this country. *Leptospira hardjo* and *szwajizak* have been isolated only from cattle.

Wild animals are important carriers of leptospiral serotypes as some of these animals shed leptospires in the urine for a year or more. Infections are most likely to spread through surface water that has been contaminated by the urine of infected animals.

Signs and diagnosis

Common clinical signs of leptospirosis are fever, jaundice, blood in the urine, reduced milk production, abnormal milk, abortions, infertility, and occasionally death. These signs are variable depending upon the pathogenicity and virulence of the infecting serotype and the susceptibility of the host. In herds infected with *hardjo* and *szwajizak*, infections are likely to be persistent, with the primary losses due to reduced milk production, infertility, and abortions. Infected cattle may excrete leptospires in their urine for several months and thus be a potential source of infection for other susceptible cattle and for persons coming into contact with the infected urine.

D. N. Tripathy is associate professor, L. E. Hanson, professor, and M. E. Mansfield, professor of veterinary pathology and hygiene.



Leptospira **(arrow) in the kidney of an infected gerbil. (Fig. 1)**

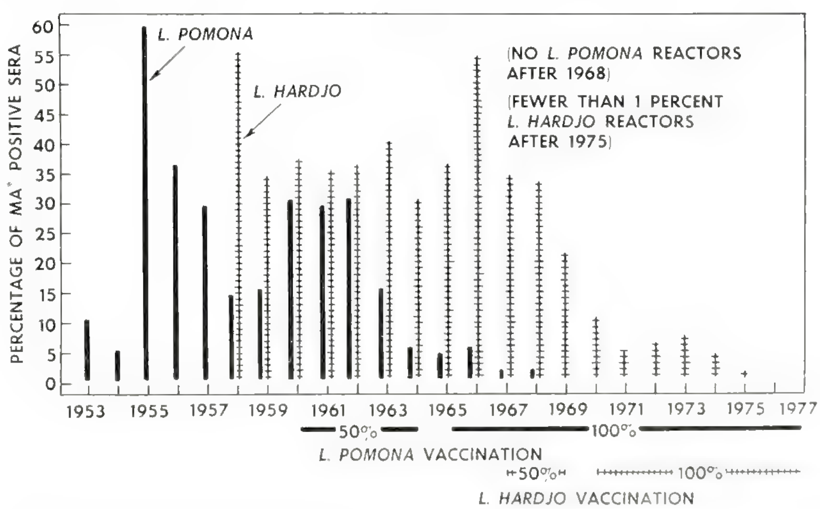
Identification of the infecting serotype is important because the antigens for a given serotype are specific only for that serotype and do not provide immunity to other serotypes. Diagnosis is usually based on testing of sera for agglutinating antibodies, cultural isolation of leptospires in a laboratory medium, inoculation of laboratory animals such as gerbils or hamsters, and demonstration of leptospires in tissues (Fig. 1).

Although presence of agglutinating antibodies in the sera of cattle is indicative of exposure to leptospires at some time, clinical signs and other tests would be needed to support diagnosis. Vaccinated animals usually do not develop high concentrations of agglutinating antibodies, but they do develop neutralizing antibodies which protect them from infection.

Infections at DSAC

Leptospirosis was discovered in the beef cattle herd at the Dixon Springs Agricultural Center in the early 1950's. This herd regularly consists of about 800 animals, including about 400 breeding cows.

Cattle on pasture in the 5,000-acre Center are quite likely to be exposed to infection. Timbered areas in and near the Center provide cover for wildlife, while numerous ponds and small lakes furnish the means by which leptospires from carrier wild and domestic animals are transmitted to the cattle herd.



Reactor rates of *L. pomona* and *L. hardjo* microscopic agglutination (MA)* antibodies in about 800 cattle sera collected annually from the herd at the Dixon Springs Agricultural Center. (Fig. 2)

Leptospira pomona has been isolated from skunks and opossums in this area, as well as from swine and cattle. Antibodies to leptospiral serotypes have been detected in deer sera, indicating that these animals have also been exposed to leptospires at some time.

Beginning in 1953, cattle sera were examined annually by agglutination test. It soon became apparent that leptospirosis was endemic in the herd, with the highest reactor rate being for *pomona*. The calf crop added new susceptible animals every year, perpetuating the infection.

Vaccination program

With the widespread distribution of leptospiral infections in cattle, swine, and wildlife, it became important to develop resistance in the cattle population through vaccination programs. From 1960 through 1964, 50 percent of the cattle were vaccinated with *pomona* bacterin every year, markedly reducing the reactor rate (Fig. 2). Since 1965, all animals have been vaccinated against *pomona* annually.

A high reactor rate for *hardjo* having been observed from 1958 to 1966, vaccination against this serotype was begun in 1967. For three years, 50 percent of the animals were vaccinated annually; since 1970, all the animals have been vaccinated. Beginning in 1974, all cattle have also been vaccinated against *grippotyphosa*.

Serologic tests in 1977 indicated that the herd was free of active infection with all three serotypes — *pomona, hardjo,* and *grippotyphosa*. Although leptospires are consistently present in the surrounding wildlife population, the annual vaccinations have stimulated protective antibodies in individual animals and have built up a collective herd immunity against leptospiral infections.

Results of the successful vaccination studies at the Dixon Springs Agricultural Center have substantially aided in the development of multiple-serotype bacterins which are now available commercially for use with cattle.

Bioavailability of Minerals In Human Soybean Foods

K. E. WEINGARTNER and J. W. ERDMAN

Soybeans have been consumed in various forms in Asia for centuries, but were not commercially produced in this country until the 1920's. By the mid-1930's, soybean oil was being used in such foods as shortening and mayonnaise, while the defatted meal found use in animal feeds. In the last 30 years, soybean production has increased dramatically and the crop's cash value is second only to that of wheat in the United States.

Human consumption lags

Utilization of whole soy products for human consumption has lagged behind production, mainly because the flavor and texture of the bean are foreign to American palates. Recently, food technologists have succeeded in preventing off-flavor in soy products. Procedures for texturizing soy protein and spinning soy fibers for meat analogs have also been developed. Since 1971 the U.S. Department of Agriculture has allowed meats in school lunch programs to be extended with as much as 30 percent soy protein. These developments, coupled with rising food costs, have resulted in increased consumption of soy-containing products in the last five to ten years.

The University of Illinois has a long history of research on the use of soybeans for human food. Research over more than 40 years has included investigations of composition and palatability of food products prepared with whole soybeans, soy protein concentrates, isolates, and textured soy protein. In addition, new food products containing soybeans continue to be developed in the food processing section of the Food Science Department. Products include soy-based flour, margarines, yogurts, beverages, and extruded products.

Questions about nutritive value

Along with increased human consumption of soy products has come concern about the overall nutritional value of soy. Soybeans are recognized as a good source of both protein (40 percent of bean) and oil (20 percent of bean). When mixed properly with other plant or animal proteins, soy protein provides excellent growth for animals. Soybeans also contain a good balance of vitamins and minerals.

It has been reported that the American diet may be marginally deficient in some of the minerals — such as zinc, calcium, and iron — that soybeans contain. However, there is a question as to whether the human body can absorb and utilize the minerals in soybean foods.

Chemical analysis of soy foods can determine how much of a nutrient is present. Unfortunately, chemical procedures do not specify the bioavailability of the nutrient; that is, the percentage that can be absorbed by the body. To determine bioavailability, animal feeding studies are necessary.

How bioavailability is reduced

The human body is not 100 percent efficient in digesting foods. As a general rule, plant foods are not as digestible as animal foods. This is partially caused by the components

K. E. Weingartner is a graduate student and J. W. Erdman, assistant professor of food science. This project is supported in part by CSRS Grant 616-15-172 under PL89-106. Other faculty involved include A. I. Nelson, M. F. Picciano-Milner, B. P. Klein, and R. M. Forbes.

of the plant cell wall, many of which are not digested themselves. They not only increase the rate at which food moves through the intestine, but may physically block efficient nutrient absorption. This undigestible plant cell wall material is usually classified as dietary fiber.

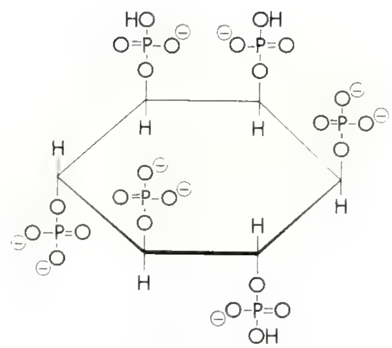
In addition, certain types of food fiber have been reported to interact chemically with minerals to reduce their bioavailability. Such chemical binding has been described between calcium and polyglucose matrices (such as cellulose); and between copper and free carboxyl groups (such as are found in hemicellulose). Soy contains significant amounts of dietary fiber, and if hulls are included in a soy food such as soy flour, the dietary fiber content can increase by 4 percent or more.

A stronger mineral binder, phytic acid, occurs in many plant foods. Soybeans, other legumes, and cereal foods contain significant quantities of phytic acid.

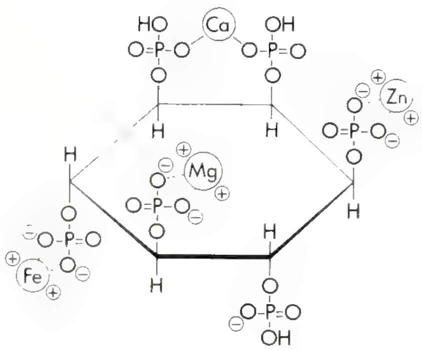
The complex is considered as the normal storage form of phosphorus in almost all seeds. Its formation accelerates during maturation of seeds and tubers. As phytic acid accumulates, it apparently chelates (binds) other minerals, forming the complex phytate. (Fig. 1) According to extensive literature, foods containing phytic acid-mineral complexes have low bioavailability of minerals because the "bound" minerals are poorly absorbed from the foods.

Research in progress

Research is currently under way at the Universitiy of Illinois to investigate the bioavailability of zinc, magnesium, iron, and calcium from processed soybean foods. Objectives are: (1) to determine mineral bioavailability from standard soy products (full fat soy flour, soy beverage base, and soy concentrate); (2) to determine the effects of standard soy products upon bioavailability of minerals from the rest of the diet; and (3) to evaluate the effects of different food processing techniques upon the bioavailability of minerals, both those added to soy products and those naturally contained in the products.



PHYTIC ACID



PHYTIC ACID CHELATE

(*Top*) Possible structure of phytic acid as it might occur at neutral pH. At this pH, phosphate groups have either one or two negatively charged oxygens. (*Bottom*) Chelation of phytic acid with various metal ions. A mineral ion may be either chelated by two phosphate groups or chelated within a single phosphate group. Although the structure of phytic acid and the mechanism of mineral binding have been studied for over 50 years, these chemical configurations (and those found in nature) are still purely speculative. (Fig. 1)

To ascertain the bioavailability of individual minerals, soy products are added to animal diets. The resultant bone or blood levels of a particular mineral are then analyzed and compared with levels produced in control animals receiving a highly available form of the mineral.

Rats are commonly used in these studies because they grow quickly and are inexpensive to purchase and maintain. Unfortunately, the rat has an innate propensity for its own feces. A rat on a normal diet will consume 35 to 50 percent of its own fecal material. Even if housed in wire-bottomed cages where the feces would normally fall through, this rodent will resort to body-contorting measures to practice coprophagy (consumption of feces). The fecal matter then goes through the intestinal tract a second time and has another chance to be absorbed.

Coprophagy can thus alter the results of bioavailability experiments, but it is often not given adequate attention. It is essential to know what percentage of the minerals in the feces is absorbed during the recycled trip in order to determine if coprophagy must be prevented in bioavailability studies. We are now conducting an experiment to answer this question.

Preliminary results

Preliminary results of experiments performed thus far have verified that zinc in soy products has low bioavailability. Calcium, magnesium, and iron have fared better than zinc in the animal tests. However, the availability of minerals varies from product to product. This may be caused by chemical or physical changes within the soy product due to the different food-processing methods used. At this time it is not known whether the reduced bioavailability of these minerals in the soy product is caused by phytate, by fiber, or by other constituents of the bean. Additional studies are planned to identify the causative agent (or agents).

The addition of soy to animals' diets seemed to have little effect on the bioavailability of zinc, calcium, iron, or magnesium from the rest of the diet. These results suggest that supplementing or extending meat with soy should not significantly affect the bioavailability of the minerals from meat even though the same mineral in the soy portion may be less readily available.

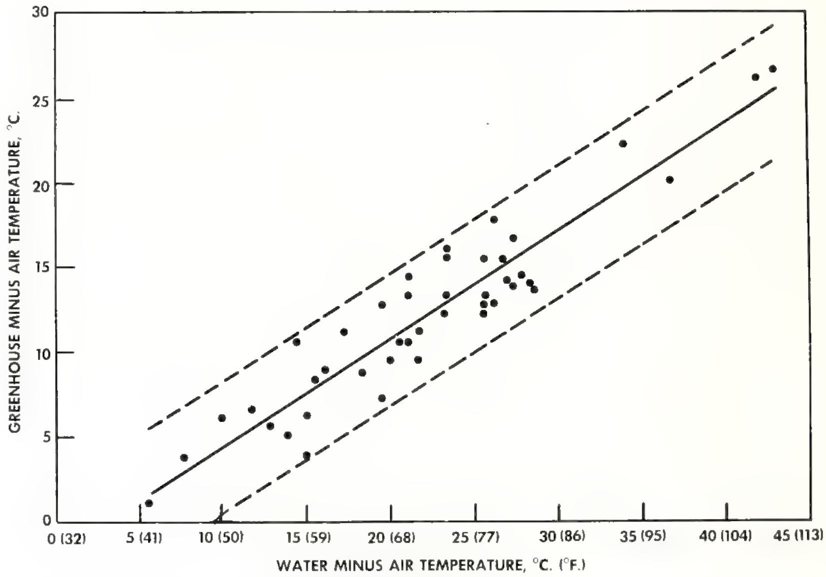
The low availability of minerals in soy could be corrected either by mineral supplementation or more simply by utilizing food processing techniques that optimize mineral bioavailability. Both measures can assure improved mineral balance and thus a more nutritional product.

Waste Energy Heats Greenhouse

PAUL N. WALKER

FOR EACH UNIT of energy generated by electric power companies, at least one unit of waste heat is discharged in heated cooling water. If an industry could utilize this low-grade heat, it would reduce its heating bill while the power companies could recoup a good part of their fuel costs by selling waste heat. In addition, both groups would be contributing to the national effort to conserve energy.

One of the most promising consumers of waste heat from power plants is the greenhouse industry. This use was suggested more than 40 years ago in the USSR and more than 10 years ago in England. Since then, numerous studies have been made on the concept.



Greenhouse minus air temperature differential as a function of water minus air temperature differential. Dashed lines represent 95-percent confidence interval for actual values of ordinate. (Fig. 1)

Types of heat exchangers

Two principal means of transferring energy from the heated water to the greenhouse have been reported. These are wet-type and dry-type heat exchangers.

Wet-type exchangers usually consist of fibrous pads, through which water flows vertically and air flows horizontally. The pads are the same kind used for evaporative cooling, but the system must be modified for heating. During cooling, outside air is forced through the evaporative pads into the greenhouse and is exhausted without being recirculated. During heating, the air is recirculated with only a minimal amount of fresh air, to minimize the heat requirement. This means that recirculating ducts must be added. Heating also calls for more evaporative pads than does cooling. Another disadvantage is the high humidity that is created inside the house.

Dry-type heat exchanges are usually metal finned-tubes. They eliminate the high humidity problems associated with the wet-type exchangers, but they are expensive and relatively large areas of the tubes are needed because of the low temperature differential between the heated cooling water and the greenhouse air.

A different type of dry-type heat exchanger is now being studied at the University of Illinois. Low-grade heated water is applied to the outside surface of the greenhouse and is then returned to the power plant. This simple heating system does not require major capital investment — there is no need for extra evaporative pads, recirculation ducts, or finned-tube heat exchangers. Moreover, humidity is not a problem because the water remains outside the greenhouse.

Description of experiment

Two small greenhouses were built at Illinois Power Company's Vermilion power plant in the fall of 1976. They were of semicircular arch cross-section construction with plastic film over a steel and wood frame. Dimensions of each were 3.7 x 7.3 meters (12 x 24 feet). One greenhouse was heated with cooling water from the power plant; the other was not heated and served as a control.

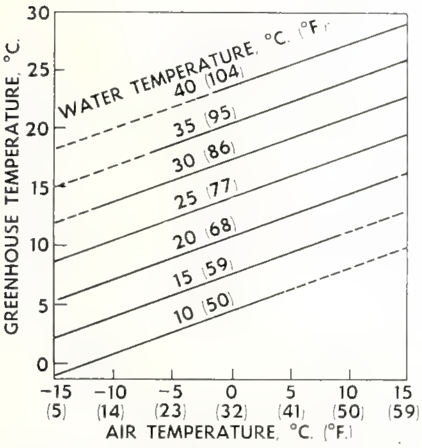
The heated water was obtained from the supply line to one of the power plant cooling towers. It was sprayed over the ridge of the greenhouse with four nozzles delivering a total of 2.5 liters per second. This amounts to 0.09 liter per second per square meter of greenhouse floor. All the greenhouse surface except the ends was covered with a film of running water.

Outside air temperature, heated water temperature, and temperature inside the greenhouses were recorded.

Temperature differentials

One datum point was taken daily from each continuously recorded temperature at the time the greenhouse temperature was the minimum for the day. Nearly always this coincided with the lowest outside tem-

Paul N. Walker is assistant professor of agricultural engineering.



Greenhouse temperature as a function of air and water temperatures. (Fig. 2)

perature and the lowest heated water temperature. The profiles of the heated water temperature and the outside temperature were similar in shape because water was transported about 60 meters from the cooling tower to the greenhouse in a poorly insulated aboveground pipe.

The best way of representing the data is by the relationship between two temperature differentials: (1) that between the heated water and the outside air, and (2) that between the greenhouse air and the outside air. This relationship is shown in Figure 1. The dashed lines represent the 95 percent confidence interval for the actual value of the greenhouse temperature minus air temperature. Much of the variation in the data points in Figure 1 is presumably due to weather factors other than temperature, such as wind speed, wind direction, and cloud cover.

The curves in Figure 2 show the minimum greenhouse temperatures that can be expected with various combinations of air and water temperatures. For example, the minimum daily greenhouse temperature is 15°C. when the outside temperature is −6°C. and the water is 30°C. and applied at the rate of 0.09 liter per second for each square meter of floor area.

In the unheated greenhouse, minimum temperature was not greatly affected by stored heat. Minimum inside temperature was never significantly above minimum outside temperature and was sometimes slightly less, presumably because of radiant cooling.

Heat use

The amount of heat used may be calculated from the water flow rate, the temperature of water supplied to the greenhouse, and the temperature of water leaving the greenhouse. Temperature of the water as it left the greenhouse was not continuously recorded. However, point checks revealed that the temperature was about equal to that inside the greenhouse. Assuming an outside temperature of −6°C. and a temperature of 30°C. for the heated water, a heat input of 5.9 kilowatts per square meter of floor area is needed to maintain the greenhouse at 15°C. With a conventional heating system, 306 watts per square meter are needed.

From the above figures, it is obvious that the surface heating system is very inefficient in its use of heat. However, this does not make the system economically undesirable because the waste heat has a presumably low, though undetermined, cost to the consumer. The cost will continue to be low until the demand for waste heat at conveniently located power plants meets the tremendous supply. At present there are few commercially attractive alternative uses for this heated water.

Even with the low thermal efficiency of this heating system, the waste heat from a single power plant can still supply heat to a large greenhouse complex. As an example, consider an 1,800-megawatt electric power generating plant. Conservatively, it would discharge 1,800 megawatts of waste heat in the form of heated cooling water. This water could heat 30 hectares (75 acres) of greenhouses. An 1,800-megawatt power plant represents only about 15 percent of the power generated in Illinois.

As previously mentioned, the experimental greenhouse was heated with a water flow of 0.094 liter per second per square meter of floor area. At greenhouse, outside, and water temperatures of 15°C., −6°C., and 30°C. respectively, 306 watts of conventional energy is an even tradeoff with 0.09 liter per second of waste water. Assuming that the heat energy in the water is free and that the only energy cost is the hydraulic head lost in moving and distributing the water, the trade-off value of the heated water is a head loss of 331 meters. With any smaller head loss, the heating system would have an energy advantage. The loss for the experimental greenhouse was only about 10 meters.

A large greenhouse could be heated more efficiently than the small one. The large structure would have a smaller ratio of surface area to floor area and thus a lower heat requirement per unit of floor area. In addition, the greenhouse ends, which were not heated on the experimental greenhouse, would make up a smaller percentage of the total surface area on a larger structure. The ends could be heated on a production unit.

The surface heating system alone may not be adequate throughout the winter, so it may need to be supplemented with a conventional system. During very cold periods the water temperature may actually be below the temperature needed in the greenhouse. Even under these circumstances, however, the surface heating system can greatly reduce conventional heating requirements. Although no heat will be transferred into the greenhouse, the water will keep the outside surface warmer than it would be otherwise and will thus reduce heat transfer out of the greenhouse. No other heating system, except a heat pump, can take advantage of the energy in a fluid that is colder than the structure being heated.

Research continuing

Further research is being conducted on different water flow rates, different methods of applying water, and the use of glass and corrugated fiberglass greenhouse coverings. A full-scale commercial greenhouse heated with power plant cooling water is being planned.

Fruit Plant Development Studied With Scanning Electron Microscopy

R. K. SIMONS and M. C. CHU

FRUIT PLANT development is usually considered a long-term process. It may take several years for an apple or peach tree, for example, to bear a profitable crop. However, a particular phase of development such as abscission or pollination will take only minutes or hours. The successful fruit grower must be an acute observer of every phase of development.

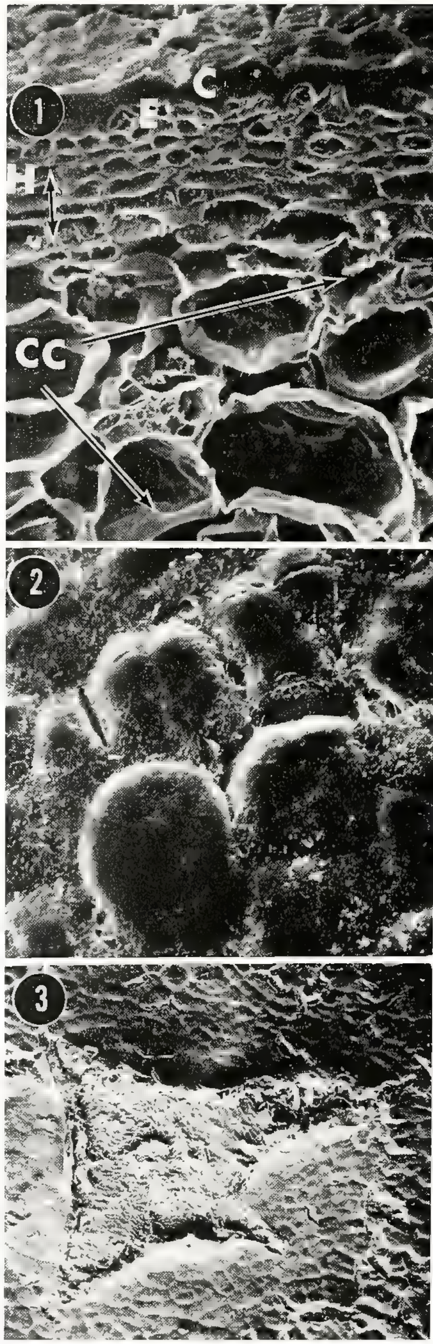
In recent years the Department of Horticulture has used light microscopy to document cellular changes during various stages of fruit plant development. This technique permits one-dimensional examination of only a very small section of plant material.

Now, with scanning electron microscopy, a larger area can be studied in three different planes. We can thus observe the interacting effects of different plant parts on development. Fresh plant material can be prepared for observation within a relatively short time.

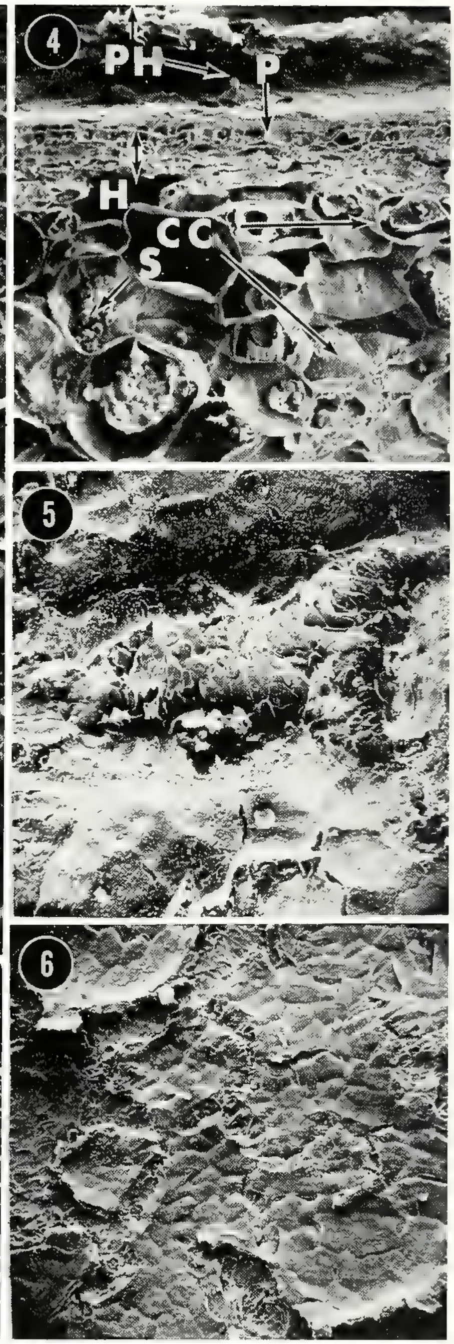
Studies conducted

Studies of fruit-plant parts with scanning electron microscopy since 1974 have included (1) development of the periderm (cork-producing tissues); (2) sequential development of the Golden Delicious apple and russet sports of that strain; (3) bitter-pit initiation in Starkrimson apples and cellular changes related to this disorder; (4) abnormalities in vascular bundles in relation to the water core; (5) fruit-spur growth, abscission, and fruit set; (6) tissue compatibility within graft unions of various

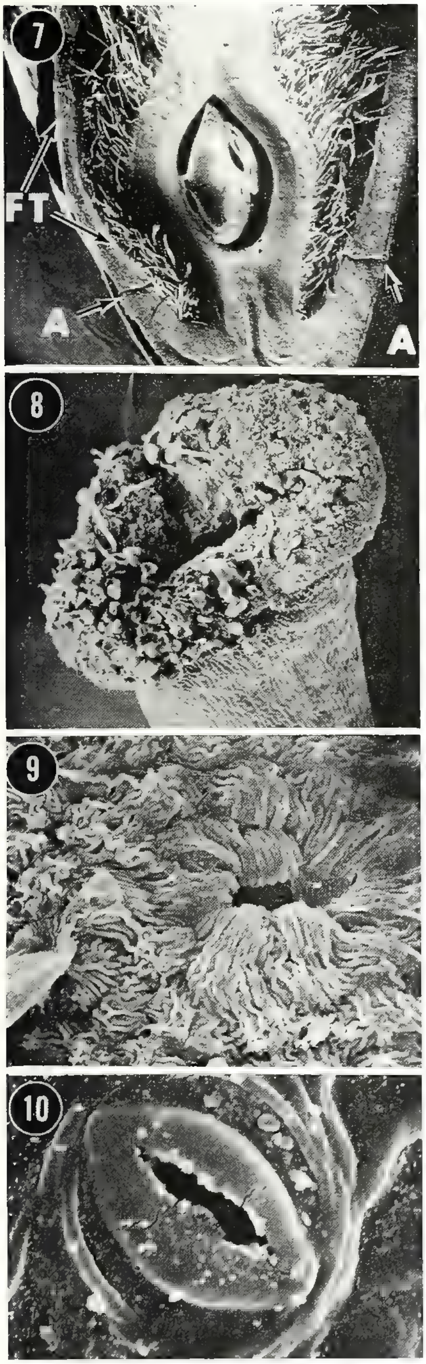
R. K. Simons is professor of pomology; M. C. Chu is assistant horticulturist.



Uninjured fruit of mature Golden Delicious. Photomicrograph No. 1 is a transverse section through cuticle (C), epidermis (E), hypodermis (H), and cortical cells (CC). No. 2 is a surface view, showing outer protective cells covered with cuticle. In No. 3, a small lenticel has enlarged with fruit growth. (Figs. 1-3)



A mature fruit in which frost injury at bloom time has persisted. No. 4 is a transverse section through cork or phellem (PH), cork cambium or phellogen (P), hypodermis (H), cortical cells (CC), and starch grains (S). Nos. 5 and 6 show russeting and breakup of cuticle on outer surface. (Figs. 4-6)



Peach-bloom development in relation to abscission. In No. 7, a longitudinal section through the fruit and floral cup base shows abscission development (A) of the floral tube (FT). No. 8 shows germinating pollen grains on the receptive stigma; No. 9, one of many stomates, surrounded by trichomes on adaxial or inside surface of the floral tube; No. 10, stomate on abaxial or outer surface. (Figs. 7-10)

apple dwarfing rootstock combinations; and (7) morphological development of apple fruit spurs.

Two of the studies — the development of russet in Golden Delicious and peach-bloom development in relation to abscission — are discussed here and are illustrated by the photomicrographs in Figures 1 through 10.

Normal vs. russeted apples

Russeting of Golden Delicious is a serious problem in Illinois. It results from this variety's sensitivity to adverse growing conditions and improper cultural practices. The photomicrographs in Figures 1-6 contrast the development of a russeted apple with that of a normal one.

A transverse section through a normal fruit (Fig. 1) shows that the cuticle, the epidermis, and the cortical cells that make up the edible fleshy portion are all well defined. In a normal fruit, the cells enlarge uniformly during growth. The well-developed hypodermis (several layers of cell thickness adjacent to the epidermis) stretches without breaking.

A thick cuticle (the waxy material on the fruit surface) partially engulfs the outer layer of the epidermis and projects into the outer layers of the hypodermis. The cuticle appears to be porous with breaks along the perpendicular cell walls (Fig. 2); its surface is rough and ridged with distorted areas. Although the cuticle may be quite thick in some places, it is very thin in others (Fig. 2).

A small lenticel on the fruit surface has enlarged during growth (Fig. 3) and is surrounded by variable cuticle thickness. An injury like this occurring at bloom time can later be accentuated by any mechanical injury, spray toxicity, or freeze damage.

It was frost injury at bloom time that caused the russeting on the fruit surface shown in Figures 4-6. A transverse section of cell-disruptive features (Fig. 4) shows the outer protective region with extensive sloughing of corky tissues which were formed from the original injury. The initial protective layers have been lost, leaving the large, fleshy cortical cells exposed to the external environment. The russeting appears as a netted pattern over the entire surface (Figs. 5 and 6). Cuticle is not evident in the russeted areas but it remains in the uninjured parts although it is very thin near the edge of the injury. Fruit injured in this way will not keep well during storage.

As we have seen, frost injury at anthesis (the time of full flower expansion) produces persisting effects on mature fruit. When injury occurs, a spray program should be adapted to prevent further injury and consequent russeting. If early injury is apparent before the excess fruit has been removed chemically, hand thinning to remove unprofitable fruit is suggested.

Peach floral-tube abscission

Thinning of peach fruits with chemicals has been difficult because growth processes at bloom time are very rapid and occur before any signs of growth are visually apparent.

The illustrations in Figures 7-10 pinpoint some of the changes during peach-bloom development. A longitudinal section through the peach flower about one day past full bloom (Fig. 7) shows the young developing fruit with seed and the development of floral-tube abscission. The fruit has been fertilized and growth is very rapid at this time.

An indicator of the developmental stage shown in Figure 7 is a stigma with germinating pollen grains (Fig. 8). After pollen tube growth has reached the embryo, the style will drop from the fruit apex.

The inside surface of the floral tube shows a mass of hairs, known as trichomes, surrounding the narrow openings called stomates. Trichomes may have an influence on the effectiveness of chemical growth regulators. Stomates are abundant on the inside surface. By contrast, relatively few appear on the outside of the floral tube and those that do occur are covered with a thick, waxy surface.

This information, plus careful, detailed observation, should increase the accuracy with which one can identify the precise stage at which fruit-thinning chemicals should be applied.

A New Covering for Arena Floors: *Wood Residue Used in Stock Pavilion*

C. S. WALTERS, T. R. YOCOM, and D. B. BAULING

For many years spent tanbark has been used as a floor covering in the University of Illinois Livestock Pavilion. However, supplies are declining, costs are rising, and in recent years the tanbark has generated an objectionable amount of dust. It was therefore decided to substitute white oak sawdust and to conduct continuing tests on the serviceability of this material. According to preliminary results, the sawdust is a satisfactory floor covering for riding rings, arenas, and similar facilities.

Materials used

The sawdust came from a barrel-heading plant where the blanks, already dressed two sides to thickness, are ripped lengthwise to make straight, parallel edges. The resulting sawdust particles are therefore longer and stringier than those produced by a cross-cut saw (Fig. 1). On an oven-dry basis, moisture content of the sawdust averaged 91 percent, ranging from 85 to 97 percent.

Four truckloads of sawdust — 92,000 pounds or 28 units — were spread on an area of 13,000 square feet. Average depth was about 3 inches. The residue was dumped on the arena floor, rough-spread with a front-mounted bucket, and leveled with a wire gate pulled flatwise over the floor. We believe that a power unloading manure spreader would have distributed the material more satisfactorily.

Some concern was expressed that the covering, when dry, would create a fire hazard. Two compounds, both deliquescent fire-retardants as well as fungicides, were sprayed on the arena floor. The south half of the floor was sprayed with a solution of zinc chloride; the north half, with magnesium chloride. Both compounds are relatively harmless to humans and the domestic animals that are ordinarily put into the arena.

The 25-cent piece in the circle serves as a scale for indicating size of sawdust particles. These particles are longer and stringier than those typically produced by cross-cut saws. (Fig. 1)

Each solution contained 50 pounds of chemical and 135 gallons of water, for about a 4.25-percent concentration. Average rate of application was about 48 square feet per gallon of solution. It took about two hours to mix the two solutions and to spray the floor (Fig. 2). At the end of the test, the performance of the two materials will be evaluated to see if one is more satisfactory than the other.

Costs

At the time the sawdust was purchased, the costs, f.o.b. Stock Pavilion, for 55 cubic yards of three types of covering materials were:

California pine bark	$3,960
Tanbark	4,962
Sawdust	379

In addition, 100 pounds of chemical for the sawdust floor cost $320 and the labor for spreading the chemicals was $33.

Spreading the covering would cost about the same for each type of material. The cost of water was also considered a constant factor. The tanbark floor was watered two or three times a day to help control dust, and after three months of service the sawdust floor was also watered. No water was applied to the sawdust floor during the first three months of service, lest it leach the chemicals from the sawdust.

Dust tests

Before the sawdust was put on the floor, we measured the dust generated by the tanbark covering. Twelve petri dishes were exposed 48 hours to collect the dust fall. On each of the two days that the dishes were exposed, a rotary broom made one trip around the arena to agitate the tanbark cover. The dust that was collected averaged 1.17 ounces per 1,000 square feet on the south side of the arena and 1.51 ounces on the north side. The difference was significant at the .05 level of probability.

Three weeks after the wood residue was applied, six collection plates were exposed, three on each side of the arena, at the same height above the floor that the tanbark samples were taken. The rotary broom made two trips around the arena in one day. On the south side of the floor (treated with zinc chloride), 1.47 ounces of dust per 1,000 square feet was collected; on the north side (treated with magnesium chloride), 2.86 ounces per 1,000 square feet.

The difference was attributed to the fact that the floor covering was

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deeper on the north side and agitation by the rotary broom created more dust. Other factors that were not measured, such as air currents due to the opening and closing of large entrance doors on the south side of the arena, also could have affected the quantity of dust in the two areas.

Fire exposure tests

The residue in a small test area was sprayed with magnesium chloride and allowed to dry. Two days later a plumber's torch was held on the treated residue for five minutes. As soon as the flame was removed, the burning wood particles went out; there was no afterglow.

A flame-spread test was also made, using a 2-foot tunnel tester. The residue was contained in a sheet steel tray 4 x 24 inches with a screened bottom. The bottom surface was sprayed with 50 milliliters of magnesium chloride, dried overnight, and exposed to the burner flame five minutes. Flame spread was low. No smoke or afterglow was observed after the flame was removed from the sample.

Service testing

Various tests continued to be made during eight months of service. Three users of the arena — Professor W. W. Albert and two of his students — were also asked for their comments on the service rendered by the sawdust covering.

Dust control. The sawdust floor covering did not eliminate the dust problem, but it did minimize it. The color of the wood dust was not so noticeable or objectionable as the dark red tanbark dust and it took less work to keep the furnishings and premises presentable.

Application rate. The original application of 7 pounds of sawdust per square foot, giving a depth of about 3 inches, was not enough. Users of the arena suggested that twice as much be applied. This is particularly important for riders and trainers of horses. A better distribution system was also recommended. Supplemental applications of sawdust should be made at six-month intervals to replace material lost through sanitation practices.

Fire hazard. The frequent watering of the sawdust could leach out the zinc chloride fire retardant. However, we believe that the recommended biweekly watering schedule would eliminate the fire hazard.

To learn how lapses in the watering schedule would affect the fire hazard, we stopped the program for two weeks. A sample of the floor covering was then oven-dried to constant weight at 105°C. Moisture content of the oven-dried sample was 18 percent. A propane torch was directed on three spots in the floor covering for one minute. All three spots showed glowing combustion but did not flame and did not expand after the torch was removed. The glow from one spot went out after one minute and from the other two, in less than six minutes. We concluded that the sawdust did not represent an unusual fire hazard and that short lapses in the watering schedule would not increase the hazard.

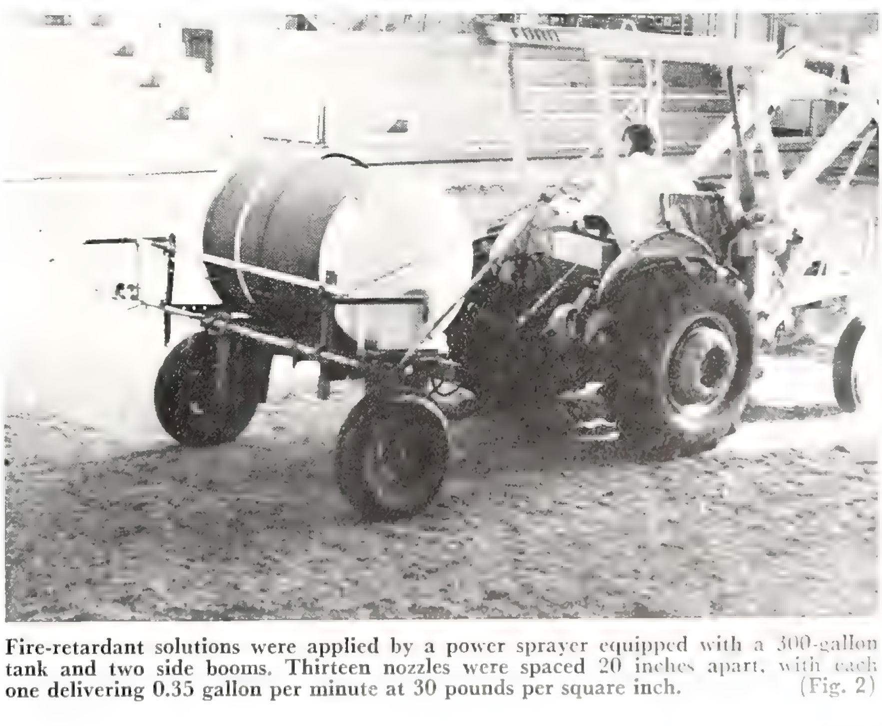
The fire retardants had been selected partly because it was believed they would absorb moisture from the air and tend to reduce the dust problem. Apparently not enough chemical was used to accomplish this purpose, and watering has been resumed.

It was reported that commercial riding stables spray the floor covering with used crankcase oil without increasing the fire hazard significantly, but no tests were made to verify the report.

Decay hazard. The wet sawdust would be subject to rapid decay in the warm, humid environment of the arena. No information was available which would indicate whether decay would be objectionable or beneficial, or whether it actually made any difference in the serviceability of the covering material.

Agitation of covering. We concluded that it would be beneficial to periodically agitate the covering by harrowing or rototilling it, perhaps as often as once a month.

Addition of sand. Arena users suggested that a "slight amount" of sand be added to the sawdust to increase the density of the flooring material and help control the dust. No tests were made to define "slight amount," but 5 to 10 percent of the volume is recommended.



Fire-retardant solutions were applied by a power sprayer equipped with a 300-gallon tank and two side booms. Thirteen nozzles were spaced 20 inches apart, with each one delivering 0.35 gallon per minute at 30 pounds per square inch. (Fig. 2)

Response of Vegetable Crops To Three Kinds of Fertilizer

ISMAIL B. HASHIM, WALTER E. SPLITTSTOESSER, and JOSEPH S. VANDEMARK

Many home gardeners this spring may be choosing among commercial fertilizer, sewage sludge, and compost as a fertilizer for vegetables. To help make this choice easier, we compared the three kinds of material in tests at the Illinois River Sand Field near Kilbourne.

The compost in the tests was one that had been used for growing mushrooms. This type of compost is similar to the compost developed in home gardens, except that it contains more nitrogen. Mushroom compost is readily available to gardeners in the Chicago area.

The soil was Plainfield sand that had extremely low exchange capacity, 0.6 to 0.8 percent organic matter, water-soluble phosphorus of 100 pounds per acre, and a potash level of 150 pounds per acre. Mushroom compost, sewage sludge (Nu-Earth), and 12-12-12 commercial fertilizer were applied at rates sufficient to make the nitrogen levels on all plots about equal to an application of 120 pounds of nitrogen per acre (Table 1). All plots were tilled to incorporate the material into the top 4 to 6 inches of soil.

Crops studied

The crops were Vates kale, Vates collards, Market Prize cabbage, Green Wave mustard, Large White Rib and Lucullus swiss chard, Tenderette snap beans, Moon Gold wax beans, Roma broad beans, Sundance sweet corn, Emerald okra, Lady Belle peppers, Dickinson Field pumpkin, Table Queen winter squash, C-28 and Jet Star tomatoes, Ruby Queen beets, Spartan Bonus carrots, Crimson Sweet watermelon, and Kenebec potatoes. Cabbage, peppers, and tomatoes were transplanted; other crops were direct-seeded.

Table 1. — Fertilizer Analysis

Fertilizer	Analysis (N-P_2O_5-K_2O)	Lb. N applied per acre
None	0-0-0	0
Mushroom compost	0.7-0.6-2[a]	112
Sewage sludge	1-1-0.1	120
Chemical fertilizer	12-12-12	120

[a] As a comparison, homeowners' compost would have an analysis of about 1.5-0.7-1.5.

Each plot consisted of 20 feet of each vegetable at each fertility level, with the middle 10 feet of row being sampled. Spacing was similar to that used commercially. Plots were weeded mechanically, and insects and diseases were controlled with approved chemicals.

Tomato fruits were harvested at three dates and total yields reported. Other crops were harvested once, when the products in the chemically fertilized plots were at optimum quality. The fresh weight of only the edible plant part is reported.

Vegetable yields

Different vegetable crops require different amounts of nitrogen, phosphorus, and potassium. Vegetables

Table 2. — Yield of Vegetables Grown at Various Fertility Levels

Vegetable	No. of plants	Fertilizer: None	Compost	Sludge	Chemical
		yield, lb.[a]			
Leafy					
Kale	30	0.9	6.2	6.7	11.7
Collards	30	1.7	10.3	8.3	17.3
Cabbage	10	6.0	20.5	28.2	28.3
Mustard	30	1.8	12.3	8.5	8.4
Swiss chard					
Large White Rib	40	0.6	4.9	1.5	1.4
Lucullus	40	1.2	8.7	6.5	3.7
Fruits					
Beans					
Snap	50	1.4	2.8	3.6	3.8
Wax	50	1.6	3.3	3.6	3.7
Broad	50	1.4	3.8	3.6	4.1
Corn, sweet	12	13.3	18.6	18.4	26.6
Okra	10	1.1	1.5	2.1	2.5
Peppers	6	4.5	7.8	6.0	6.4
Pumpkins	10	86.0	242.0	345.0	436.0
Squash, winter	10	18.0	60.0	59.0	60.0
Tomatoes					
C-28	10	34.9	47.1	66.1	83.8
Jet Star	10	35.9	99.5	98.8	99.9
Watermelon	10	190.0	150.0	255.0	250.0
Roots and tubers					
Beets	50	0.4	8.3	6.8	9.8
Carrots	50	0.4	1.2	1.3	0.9
Potatoes	10	14.7	26.5	30.0	27.0

[a] Tomatoes were harvested three times, other vegetables once.

Ismail B. Hashim was formerly a graduate student in horticulture; Walter E. Splittstoesser and Joseph S. Vandemark are professors of horticulture.

grown without any fertilizer often showed nutrient deficiency symptoms. Many vegetables grown with compost or sludge received adequate amounts of nitrogen and phosphorus but were deficient in potassium.

Crops such as kale, beans, sweet corn, winter squash, Jet Star tomatoes, and carrots produced equally well on compost or sludge (Table 2). Others such as cabbage, pumpkins, and tomatoes, produced more when grown with sludge than with mushroom compost. In general, vegetables grown with balanced nitrogen, phosphorus, and potassium produced the highest yields. Mushroom compost provided balanced feeding for some vegetables; a complete chemical fertilizer was more satisfactory for others.

Dangers of sewage sludge

Raw sewage should not be applied to garden soil as it may carry human diseases which are absorbed by the plant and found in the edible part. Heat-treated sludges are normally safe from a sanitary viewpoint.

Another potential hazard is the toxicity from heavy metals such as cadmium, which are usually found in sludges from industrial areas. Leafy and root vegetables are quick to accumulate a toxic element like cadmium.

Sludges containing more than 50 ppm of cadmium probably should not be used on vegetable gardens. Sludges containing less than this amount may be used at levels that do not exceed 250 pounds per 1,000 square feet. If a sludge is derived from a community with no heavy industry, it is probably safe for vegetable crops. Most sludges may be used on lawns, flowers, shrubs, and trees.

Dividends From International Tests of Soybean Varieties

H. J. HILL, H. C. MINOR, and D. K. WHIGHAM

In much of the world, especially in tropical and subtropical areas, people are getting far too little protein in their diets. One way of correcting this deficiency is to increase the use of soybeans as human food. With good yields soybeans compare favorably with other crops in protein production per unit of land area, and the protein is of high quality.

The desire to expand the use of soybeans as a food crop in developing countries led to the formation of the International Soybean Program (INTSOY) in 1973. This is a cooperative venture of the University of Illinois at Urbana-Champaign and the University of Puerto Rico, Mayaguez Campus. It is supported by the U.S. Agency for International Development.

Shortly after INTSOY was organized, leaders of the program launched the International Soybean Variety Evaluation Experiment (ISVEX). It is designed to test soybean varieties under a wide range of conditions and identify those that are adapted to the tropics. The experiment also provides for exchanging information among research workers in different countries and comparing performance of locally adapted and introduced varieties.

INTSOY provides seeds, inoculant, and detailed instructions for conducting the trials. Data collected

INTSOY spacing trial at Lajas, Puerto Rico.

H. J. Hill is assistant agronomist. H. C. Minor and D. K. Whigham were formerly assistant professors of agronomy.

Table 1. — Mean Yields (1973-1975) of Five Highest Yielding Cultivars in Three Environmental Zones[a]

Variety	Zone 1[b]	Zone 2[c]	Zone 3[d]
	kilograms/hectare (bu./A.)		
Bossier	2,330(35)	2,052(30)	1,945(29)
Davis	2,303(34)	1,976(29)	1,649(24)
Hardee	2,254(34)	1,987(30)	1,669(25)
Jupiter	2,174(32)	1,956(29)	...
Forrest	2,174(32)	1,930(29)	1,779(26)
Williams	...	...	1,521(23)

[a] Altitude at all sites below 500 meters.
[b] Mean of 70 sites; 10° latitude or less.
[c] Mean of 59 sites; 11°-20° latitude.
[d] Mean of 18 sites; 21°-30° latitude.

by the cooperating agronomists are returned to INTSOY for analysis. In 1973, 90 trials were conducted in 33 countries. By 1975, these numbers had grown to 257 trials in more than 90 countries.

Much has been learned from the ISVEX by both cooperating and coordinating scientists. The knowledge has already produced many dividends and should eventually result in a more productive and secure soybean crop for growers everywhere.

Variety performance

One dividend of the experiment has been the identification of varieties that produce high yields under a range of environments. The five highest yielding varieties in three selected environments are given in Table 1. These cultivars are commonly grown in the southern United States and represent maturity groups IV through VII. Varieties of U.S. origin often yield better than locally developed varieties, even near the equator. Although the mean yields appear rather low, some varieties in these trials have yielded more than 4,000 kilograms per hectare (60 bushels per acre).

Utilizing information from variety trials at 25 locations between 3° and 19° latitude, INTSOY scientists have been studying the relative effects of management and environmental variables on the grain yield of 10 varieties. Management variables were: amount of N, P, and K fertilizer applied, mean nodule number, nodule dry weight, and plant population. Environmental variables were: altitude, latitude, day length, maximum temperature, and minimum temperature.

All management variables together accounted for 56 percent of the variability in yield among locations. Environmental variables accounted for only 27 percent of the variation. The relative importance of the management variables suggests that farmers everywhere should be trained in the proper management of soybeans.

Seed quality

In some regions of the United States and at many tropical locations, warm, humid conditions during maturation reduce soybean seed quality. After harvest, these same conditions shorten the seed's storage life. In the humid tropics, soybean seed must be dried and stored in moisture-proof containers or under refrigeration to maintain viability. Varieties differ in the quality of seed produced under poor field and storage conditions. Hardee, for example, is a consistently high yielder (Table 1), but it produces seed of such poor quality that its use has been discouraged.

To study the problem of seed quality, INTSOY staff stored numerous genotypes in a simulated tropical environment (30°C. and 80 percent relative humidity). Maintenance of viability was found to be highly correlated with a hard seed coat. Work is now under way to study the inheritance and other properties of this characteristic. If it can be transferred into highly productive varieties, the seed production and storage problems of the humid tropics and certain U.S. soybean production areas may be partially solved.

Soybean pests

Research linkages strengthened by the international variety experiments have increased the opportunity to identify and study soybean pests which at present have a limited distribution in the United States, or do not occur at all. These experiments also provide a mechanism for evaluating the reactions of U.S.-developed varieties to diverse pests not yet found in this country.

Social benefits

One of the most important dividends from ISVEX may be social rather than technical. Introducing soybeans as a new food crop into areas suffering from protein and caloric deficiencies may improve human nutrition and well-being, and possibly contribute to political stability and development. However, adoption of soybeans in developing countries is not a rapid process. As in the United States, successful farm production is highly dependent on good production and harvesting practices. Commercial production depends on attractive prices and an economic system capable of providing production inputs, local marketing outlets, research capacity, and farm and consumer education programs. In many countries where soybeans have potential as a food crop, the required technical and social infrastructure needs improvement.

Questionnaire

To continue as a cooperative program, ISVEX must be of mutual benefit. A questionnaire was sent to all ISVEX cooperators to help assess their interests, needs, and capabilities.

When asked if soybeans would be used as a human food, 80 percent of the cooperators said yes. One-fourth reported that soybeans are currently being utilized for human food. Nearly three-fourths (73 percent) of the cooperators also reported that there is good potential for acreage expansion. These results support the view that there is a potential for expanding production and utilization of soybeans as human food in the tropics.

Cooperators indicated in the questionnaire that INTSOY can be of further assistance by exchanging new varieties and breeding lines; sending information on production and management; and assisting in personnel training. INTSOY has strong programs in all three of these areas. The questionnaire results suggest that the emphases to date are appropriate first steps for attaining program objectives, but that further work will be needed.

Five Staff Members Are Honored

In the eighth annual Paul A. Funk Recognition Program, held February 24, five College of Agriculture staff members received citations and cash awards for "outstanding performance and high achievement." Funds for this program are provided by the Paul A. Funk Foundation of Bloomington.

The major achievements of the award winners are briefly summarized in the following paragraphs.

Thomas Applegate Hieronymus

A world-renowned authority on agricutural commodity futures markets, Professor Hieronymus is equally respected in both trade and academic circles. His book, *Economics of Futures Trading,* exemplifies his ability to effectively communicate a very complex subject to a wide audience.

He has significantly affected public policy regarding commodity markets. With his expert testimony before Congressional committees and the courts, he has helped shape the regulation of such institutions as the Chicago Board of Trade and the Chicago Mercantile Exchange. His evaluation of commodity markets influenced the development of the Commodity Futures Trading Commission Act, passed in 1974.

Professor Hieronymus has been active in grain marketing extension since 1948. His recent reorganization of formerly independent programs into a Price Forecasting and Sales Management Group has become a model for extension work in production and marketing strategies.

Ellery Louis Knake

Professor Knake is a distinguished weed scientist whose research has provided economic justification for using much of today's weed control technology and has also led to improved herbicide performance. He advocates the integration of chemical and nonchemical methods of pest management and has actively promoted realistic rather than overly restrictive regulation of pesticides.

As an extension educator, Professor Knake is widely recognized for effectively communicating modern weed control technology to farmers and others. Recently he helped establish the multidisciplinary Plant Clinic at the University.

In 1972 he was the first recipient of the Weed Science Society of America's Outstanding Extension Worker Award and also received the CIBA-Geigy Award for Outstanding Contributions to Agriculture. Among his other honors, he has been elected a Fellow of both the American Society of Agronomy and the Weed Science Society of America.

Frederick August Kummerow

Professor Kummerow's research on lipids has won him an international reputation. His work has helped put into perspective the relationship between the consumption of animal food products and cardiovascular disease, the leading cause of death in this country. In another area of research, his work on hydrogenation of fats has led to the adoption of new technologies to produce food-grade fats and oils.

Among the honors he has received have been the presidency of the Chicago and Illinois Heart Associations, and membership on the Committee on Fats and Oils (American Representative), National Research Council, National Academy of Sciences.

He was instrumental in establishing the Burnsides Research Laboratory, where his administrative abilities have facilitated productive multidisciplinary research on arterial tissue. He is also highly regarded for his exceptional graduate training programs.

Queenie Beatrice Mills

As head of the Division of Human Development and Family Ecology, Professor Mills has developed an innovative, interdisciplinary program of teaching and research that emphasizes family relationships and encompasses all stages of the life-span.

In 1964 she initiated at the Child Development Laboratory one of the first intervention programs in the United States for preschool children from low-income families. The next year she was a member of the group that planned and launched the national Head Start program. She later served as planner and codirector of the federally funded Leadership Development program for disadvantaged preschool children and for parent education.

Professor Mills is the author or coauthor of many publications on reading instruction for young children. Her books, manuals, nationally standardized tests, and teaching materials are used throughout this country and in Canada and Australia.

William Michael Sager

During more than 20 years as extension adviser in Woodford County, Mr. Sager has contributed notably to the county's agriculture.

One major program has been aimed at renewing farmers' and landowners' interest in soil conservation. As a result, 75 percent of the county's tillable land was under conservation tillage by 1977. For this leadership, Mr. Sager and his associates in the SCS and ASCS received the USDA Unit Award for Superior Service. Among other projects, he helped establish one of the first county beef improvement associations in Illinois.

His influence has spread beyond Woodford County through his weekly news column, articles in farm magazines, and service as a specialized crop production adviser. In six overseas assignments he has helped farmers in Peru and Panama begin soybean production.

Especially outstanding is his effectiveness in counseling, encouraging, and motivating those he serves.

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FARM BUSINESS TRENDS

THE 1970-1971 PERIOD represented a turning point in national pork production (see chart). From 1955 to 1970, per capita pork consumption (carcass weight basis) ranged from 65 to 82 pounds per person, following a cyclical pattern often referred to as the four-year hog cycle.

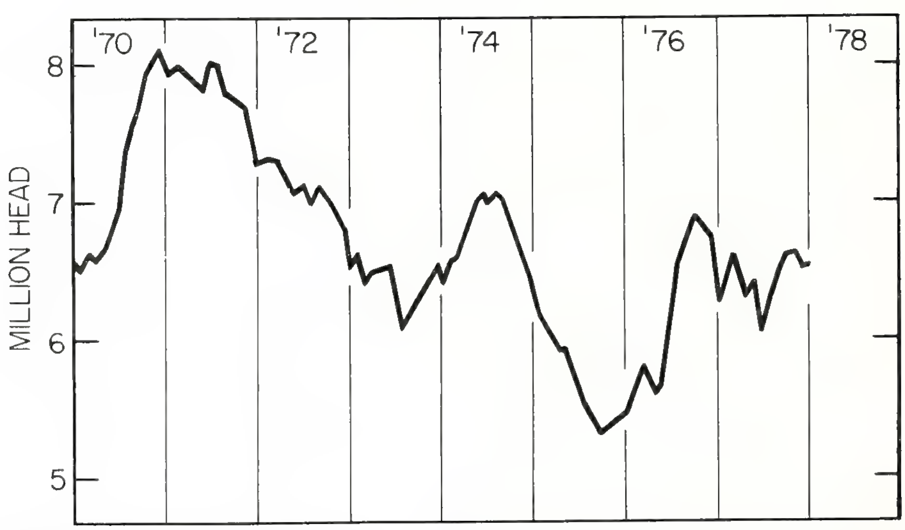
In absolute numbers, total commercial slaughter in 1971 was at an all-time high of 94.4 million head. With expanding population, however, the per capita consumption that year was 79 pounds.

After 1971, pork production trended downward to a commercial slaughter in 1975 of 68.7 million head. This translated into a consumption of only 56.1 pounds per person, a record low in per capita pork consumption for contemporary history.

Total production in 1977 was 77.3 million head, for a per capita consumption of 61.8 pounds, up 10 percent over 1975. The March 1, 1978, Hogs and Pigs Report indicates little or no expansion in total pork output for 1978 over 1977.

A second trend in pork production has been observed. This is an improvement in carcass quality, represented by the reduction in lard trimmed off the hog carcass when pork is prepared as retail cuts in supermarkets. In 1957 the 75.1 pounds of pork consumed per person, measured by carcass weight, resulted in 56.6 pounds of retail cuts. In 1977, 61.8 pounds of pork per person in carcass weight provided 56.5 pounds of retail cuts. Between these two dates, 1957 and 1977, per capita consumption of pork in the form of retail cuts did not change. But the lard trim available for shortening and cooking purposes was reduced by 13.2 pounds per person.

As a result of the improved carcass quality, both the consumer and the pork producer have gained. The consumer has available a higher quality of product. The producer, by substituting lean meat for the much lower valued lard trim, benefits from the higher cutout value of the hog carcass. — *A. G. Mueller, professor of agricultural economics*



Monthly commercial hog slaughter, 1970-1977 (given as 3-month moving average, so that seasonal variation is removed).

Summer, 1978

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

IN THIS ISSUE

The nutritive value of agricultural residues treated in various ways is determined by simulating rumen conditions in test tubes (page 10).

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE Volume 20, Number 3

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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(Cover picture by Larry Baker)

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CORRECTION, page 14, Spring issue: Soybean cultivars in the variety performance tests represented maturity groups III through IX rather than IV through VII.

DR. SALISBURY RETIRES

AFTER 31 YEARS with the University of Illinois, G. W. Salisbury is retiring this summer as director of the Agricultural Experiment Station. He was head of the Department of Dairy Science from 1947 until 1969, when he took over his present position. He had previously been on the staff of Cornell University.

Dr. Salisbury has had a distinguished career as both an administrator and a scientist. His major research interests have been concerned with the reproduction of dairy cattle, with emphasis on artificial insemination. Results of his experiments are being applied every day in the artificial breeding of dairy cattle throughout the world. His research with the spermatozoa of cattle, rabbits, and frogs has yielded extensive information on the aging process, which may apply to all cells and tissues.

Through the years he has accepted many assignments of national and international scope. For example, he served on the Agricultural Subpanel of the Presidential Science Advisory Committee for President Kennedy, 1961-1963; was a consultant to the U.S. Office of Science and Technology in 1962; was a director of the International Dairy Show, Chicago, 1953-1970; and was a consultant on the advisory panel of basic agricultural research from 1976 to 1978 under the Congressional Office of Technology Assessment. Overseas assignments have taken him to Holland as a Fulbright lecturer; to Greece as a consultant on agriculture to the Greek government; and to J. Nehru University, India. He was also honorary scientific consultant on the Milk Marketing Board of England and Wales and the Ministry of Agriculture and Fisheries.

Among the honors he has received for his contributions to animal agriculture have been the Borden Award (1945); the Morrison Award (1964); Award of Merit, Fifth International Congress of Animal Reproduction and Artificial Insemination (1964); Order of Knighthood "Cavaliere Ufficiale nell'Ordine Al Merito della Repubblica Italiana," presented by the president of Italy (1966); Paul A. Funk Award (1972); award presented by the Italian government (1972); election to the National Academy of Sciences (1974); and Distinguished Service Award of the American Dairy Science Association (1978).

Although Dr. Salisbury is approaching retirement, he continues his keen interest in agricultural research, as is exemplified by the article which appears on the following pages.

Agricultural Research Policy:
What Does the Future Hold?

G. W. SALISBURY

During the past century and more, Congress — with the cooperation of the state legislatures — has established a system unique in the world for generating and distributing new knowledge about agriculture and rural life. The system encompasses land-grant colleges to educate people about agriculture and mechanic arts, state experiment stations to study and resolve agricultural problems, and the extension services in agriculture and home economics to deliver research information to the people.

Looking back on the history of U.S. agricultural research and extension accomplishments, it is clear that the system is time-proven and productive. Each unit of the present system was established in response to different priorities set by society as it grew. Now an encroaching world population and dwindling reserves of natural resources present new priorities for future agricultural research.

Incorporating the past

Characteristic of all sciences is the cumulative process of incorporating what has been learned in the past with what is being sought for the present and future. In most human endeavors the lessons learned, either by success or failure, create new ideas to be tried. The U.S. system of agricultural research provides a continuous relay of the brainpower, manpower, and experience needed to develop research ideas. Also built into the system is a continuous transfer of information and ideas from the scientists to the teachers to the practitioners, and from the practitioners back to the teachers and scientists.

Agricultural research has had some of the greatest successes known to man; perhaps not as spectacular as a walk on the moon, but certainly more beneficial to more people. In fortunate combination with soil, climate, water, and human resources, agricultural research has afforded a relatively small segment of the world's population with elements of a "good life" beyond basic survival.

It has had its failures too. One is that neither the facts generated by agricultural research nor the people who have generated them have played much of a role in political decisions. It would appear that in the coming decades the facts, if not the people, must have an increasing role.

Integrating a new plan

Since September 29, 1977, there has been widespread speculation about the future of U.S. agricultural research as we've known it for 100 years. That was the day President Carter signed the Food and Agriculture Act of 1977 including Title XIV, cited as the National Agricultural Research, Extension, and Teaching Policy Act.

Title XIV recognizes that "the existing agricultural research system consisting of the federal government, the land-grant colleges and universities, other colleges and universities engaged in agricultural research, the agricultural experiment stations, and the private sector constitute an essential national resource which must serve as the foundation for any further strengthening of agricultural research in the United States." However, it says that the work conducted by these agencies is not fully coordinated, the information produced is not being efficiently transferred to the people, and the agencies have only partially responded to the needs of all persons affected by their research.

The act acknowledges that federal funding levels for agricultural research and extension in recent years have not been commensurate with needs stemming from changes in U.S. agricultural practices and the world food and agriculture situation. Responsibility for not fully responding to the needs of the people must therefore rest not only on the agencies conducting the research, but also on the makers of past national policy.

The new policy enunciated in the 1977 act is to "undertake special measures to improve the coordination and planning of agricultural research, identify needs and establish priorities for such research, assure that high priority research is given adequate funding, assure that national agricultural research, extension and teaching objectives are fully achieved, and assure that the results of agricultural research are effectively communicated and demonstrated to farmers, processors, handlers, consumers, and all other users who can benefit therefrom."

Many diverse research areas were identified in the act as needing special emphasis. Among them are the search for alternatives to technologies based on fossil fuels; environmental problems caused by techno-

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G. W. Salisbury, director of the Illinois Agricultural Experiment Station, is retiring August 31 after an outstanding career as scientist and administrator (see page 2).

logical changes; energy conservation; forestry; aquaculture; and management of natural and renewable resources. Still other research initiatives are to be directed at improving human nutrition and exploring areas in home economics. Also marked for high priority are climate, drouth, and weather modification; the needs of small farmers and the family farm system; export markets; efficient production, processing, marketing, and utilization of food, fiber, and non-food products; animal health care; new crops; and use of organic waste materials on agricultural land.

To implement these and other new research programs and improve existing ones, the act authorizes increased funding and establishes a new system of grants for high-priority research to be awarded on the basis of competition among all scientific research workers and among all colleges and universities. The competitive grants program is fueled by part of the money formerly appropriated to the land-grant universities and their experiment stations.

Will the act strengthen agricultural research? Or will it disperse fiscal and intellectual resources away from the best interest of agriculture? Do the framers of the act expect that newcomers to agricultural research can gear up and accomplish over the next five years what a system already organized and equipped to conduct agricultural research has failed to accomplish in its 100-year history?

It is not easy to develop such finely tuned and competent research instruments as you will find in the state agricultural experiment station system. And it will be costly to replace them.

Anticipating the future

The goals of future agricultural research efforts are really no different from those of past research. Certainly agricultural methods, as a result of research, have changed dramatically. Yet the basic goal of the scientific study of agriculture is to maintain a continuing trajectory for providing the needs and wants of society.

Agricultural researchers serve as outriders or scouts for society as it approaches new frontiers. Their function is to keep far enough ahead of the pace of normal experience to route society around areas of potential danger.

As advances in communications narrow the distance between the people and the problems, people become aware of more problems. Demands on researchers for useful information will continue to increase as the number of farmers engaged in productive agriculture decreases and the population continues to push to the limit the resources needed for individual survival.

Future research in agriculture will cover many subjects. It will explore the potentials for genetic increase in the yield per unit of crops and livestock. It will seek to protect those potential gains against losses caused by disease and other environmental influences.

Agricultural researchers will explore the effects of air pollutants on the growth and development of plants; the impact of human beings on commercial forests; and the effects of technology on the land and the people.

Agricultural researchers will consider the care necessary to produce intact grain seeds and will examine the brutal bulk shipment of that grain by truck, train, barge, and ship to remote markets of the world.

They will stimulate young minds to preserve the continuum of research and information transfer. As in the past, agricultural researchers will learn from their successes and mistakes. The application of their new knowledge will result in differential benefits and costs to various segments of the population, imperfectly estimated before the fact by decision makers.

Many people will go hungry unless researchers can generate information on the limits of food productivity and of equitable distribution to people unable to feed themselves. This seems like an impossible task, and perhaps it is, because we do not at present know what limits agricultural productivity in many areas of the world.

We know that some people rail against the use of grain to feed livestock, particularly beef cattle, even though those cattle can turn coarse feeds unusable to man into nutrients essential to human growth and physical well-being. Others advocate using feed grains to produce "gasahol" for use in internal combustion engines. As fossil oils become scarcer, the energy needs of the rich nations' cars may become more competitive with the world poor for feed grains than cattle ever have been.

We are said to be running out of arable land, but few seem to really care. Although people talk about rational land use, they refuse to adopt public policies consistent with the capacity of the land to produce food. Perhaps in regions of expanding human numbers, the use of land to produce food will not become competitive with other human demands until the day after the last adequate meal.

The United States and other advanced countries have societal models for training their young to the need for food and the methods of producing it. Few of the less developed countries do. In the United States, the land-grant universities and the state agricultural experiment stations form the model for generating research information necessary to develop technology; the Cooperative Extension Service is the societal model for transferring the technology to the people who need it.

Whether we like it or not, the American system of agricultural production is highly integrated and composed of many elements, both public and private. The public sector is the primary generator and transmitter of knowledge essential to decision-making in the private sector. Without the one, the other's effectiveness suffers. One wonders, in the long pull, whether the American society has the knowledge and the wisdom to make the long-range investments and the timely judgments required to sustain adequate food production.

Two Useful New Tools For the Food Industry

MUNIR CHERYAN

SCIENTISTS can now attack energy- and environment-related problems with two relatively new tools: reverse osmosis (RO) and ultrafiltration (UF). Both are membrane separation processes. Already they have been put to a variety of uses, from the desalination of seawater to the recovery of nutrients from food plant wastes.

Membrane separation processes are based on the phenomenon of osmosis. This is the ability of semipermeable membranes to discriminate between molecules on the basis of molecular size, shape, and, to a lesser extent, chemical composition. Osmosis was demonstrated as long ago as 1748, but the concept remained a laboratory curiosity until the early 1960's, when synthetic anisotropic membranes were developed that produced reasonably high flux (dewatering rates) and could withstand high pressures.

For both RO and UF, feed solution is pumped under pressure over the surface of the membrane. In reverse osmosis, the membrane rejects all components of a solution except water. Consequently, the osmotic pressure in the feed stream is quite high and operating pressures of 500 to 1,500 psig are common. In effect, RO is essentially a dewatering technique.

By contrast, UF is not only a dewatering technique, but also a method of fractionation, purification, and macromolecule concentration. The membrane retains only materials with large molecular weights, while solutes with low molecular weights pass through the membrane. Pressures for UF — generally 25 to 100 psig — are much lower than for RO. Permeability and selectivity characteristics of the membrane can be controlled during its manufacture by varying the pore sizes or "molecular weight cut-offs."

Ultrafiltration and reverse osmosis are the first continuous molecular separation processes that do not involve a change of phase or state of the solvent or interphase mass transfer. The implications of this are what interests food processors.

Whey treatment

An important use of membrane separation processes is the treatment of whey, a by-product of cheese manufacture. Each year, U.S. cheese factories produce more than 30 billion pounds of whey, most of which is merely discharged into sewers. With a biological oxygen demand (BOD) of 50,000 ppm, the discarded whey is a major pollutant. Moreover, it contains over 100 million pounds of protein with excellent nutritional properties. This waste of whey cannot continue, because cheese factories are being required to find other methods of disposal, pay sewer use premiums, or discontinue manufacturing.

Until now it has not been feasible to recover whey protein for use as human food. Large amounts of water must be removed to concentrate the protein to usable levels; the protein is likely to deteriorate with heat treatment; and the whey contains high concentrations of salt and lactose relative to protein.

Ultrafiltration can overcome these limitations. Because UF removes water without changing its form, this process requires much less energy than such conventional methods as evaporation and freeze-drying. For example, evaporation requires 1,000 BTU per pound of water removed; UF, 5 to 15 Btu — which is what is needed to operate the hydraulic pump. RO would require 100 to 300 Btu because osmotic pressures are higher than for UF. Neither UF nor RO requires expensive equipment for generating or transferring heat, and the membrane operation can be far from the prime power source.

Not having to change the form of the water means that processing can be done at ambient temperatures, minimizing any freezing or thermal damage to protein or other food constituents. Proteins produced by UF are thus superior in some respects to those produced by conventional processes.

Another major advantage of UF is its simultaneous fractionation-concentration capability. By proper choice of membrane and operating characteristics, undesirable solutes having low molecular weight can be selectively removed from a solution. A one-stage UF process can change the protein-to-lactose ratio of cheese whey from an undesirable 11:89 to a more useful 55:45, and at the same time remove 90 percent of the water. Similarly, in our research, we have removed substantial amounts of oligosaccharides and phytic acid from soybean water extracts simply by removing 90 percent of the water, thus producing a purified, concentrated, and highly useful soy protein concentrate.

Limitations and further uses

There are some limitations to the use of membrane processes. For example, they cannot take a product to dryness. Also, along with the undesirable solutes, some useful ones such as vitamins and minerals may be lost in the permeate. Disposal of permeate from UF processes is still a problem, although permeate from RO is essentially pure water that can be reused in the plant.

At present the food industry is applying membrane processes in a variety of ways. Two examples are the recovery of sugar from coconut processing wastes and the manufacture of soft cheese. The processes are being constantly refined, improving their usefulness both in attacking environmental and energy problems and in producing a new generation of food ingredients and products.

Munir Cheryan is assistant professor of food process engineering.

Corn Anthracnose Leaf Blight and Stalk Rot Spread Into Illinois

DONALD G. WHITE and JANET L. YANNEY

ANTHRACNOSE is a disease that affects a large number of grasses including corn, sorghum, and wheat. It is caused by *Colletotrichum graminicola,* a fungus with many strains. A strain producing anthracnose on one host species may not necessarily affect any other species.

Before 1970, anthracnose was considered a minor disease in corn. However, it had caused serious losses in grain sorghum and broomcorn. As early as 1940, yields of broomcorn in Douglas and Coles Counties were reduced by 90 percent.

Since the early 1970's, corn anthracnose has become much more prevalent. It is especially serious in an area including the southeastern states and extending north and west into Illinois. In 1972, anthracnose completely destroyed 100 acres of sweet corn in Benton County, Indiana. Since then, other sweet corn fields and hybrid dent corn production fields planted with very susceptible inbreds have also been completely lost. In 1975, a number of Illinois fields with rotting stalks and prematurely dying plants were examined and *C. graminicola* was found in 78 percent of them. This increase in the occurrence and severity of anthracnose has prompted research on all facets of the disease.

Symptoms

Leaf blight and stalk rot are the most commonly seen and probably the most important phases of this disease. However, *C. graminicola* can infect most plant parts including the shanks, kernels, and roots.

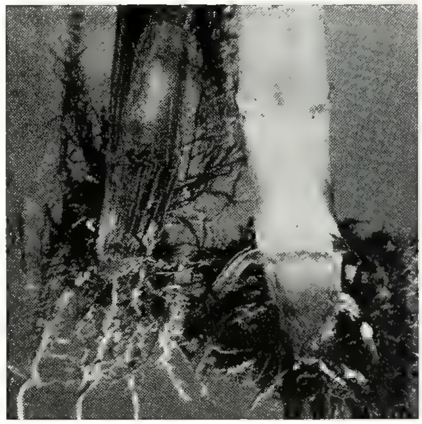
Leaves may become infected during any stage of growth. Symptoms vary greatly depending on genotype, age of the leaf, and environment. Lesions on susceptible plants are light tan, oval to elongate, and ¼ to ¾ inch long. Some lesions may have a red to yellow-orange border. The lesions may expand and coalesce, blighting the entire leaf. On resistant plants, lesions are usually smaller and are chlorotic to necrotic. On some genotypes, lesions may be full-sized but may not expand to cause extensive blighting.

Under dry conditions, lesions may appear as small chlorotic spots which may enlarge as plants age or as conditions become more favorable for disease development. Commonly, these symptoms are first seen on the lower leaves and progressively move up the plant to upper leaves.

Stalk infections become evident at various stages of growth depending on the susceptibility of the plant. For example, the lower stalk tissues of the highly susceptible inbred C123 may be so severely rotted in early growth that the plants are killed even before pollen production (Fig. 1). Most other inbreds and hybrids are not affected until a short time before normal senescence.

In some cases, portions of the plant above the ear blanch and die four to six weeks after the plant silks while the lower portions of the plant remain green. Later, these tops may top-lodge and fall off. In other cases, entire plants are prematurely killed and lodging may result (Fig. 2).

A shiny black discoloration on the exterior of the stalk is typical. The discoloration may be uniform or may occur as blotches or speckles. It may cover the bottom few internodes only or the entire length of the stalk (Fig. 2). The interior pith area of the stalk is often blackened or discolored. The stalk may sometimes, but not always, be easily crushed between the fingers and thumb.



Plant killed by early stalk infection (*left*) and healthy plant. (Fig. 1)

Favorable conditions

The fungus overwinters in association with the leaf and stalk tissues of previously diseased corn plants. Spores are produced in fungal structures called acervuli and are spread by splashing water.

Leaf blight is commonly seen early in the spring in fields where corn debris from the previous year has been left on the soil surface. Usually, leaf infection is found first in the lower leaves and moves to the upper leaves as the season progresses.

Leaf blight is likely to be common in late fall as well as early spring, depending on weather conditions. In 1974, 1975, and 1977, when August and September rainfall was heavy,

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Plant that has been killed and lodged (*left*), and stalk with the shiny black discoloration typical of anthracnose infection. **(Fig. 2)**

leaf blight was prevalent in the fall. However, the late summer and early fall of 1976 were dry and late-season blight was relatively low. Leaf blight late in the fall is not necessarily associated with large amounts of debris on the soil surface.

The mechanisms for infection of stalks are not yet completely understood. Some workers believe that spores washed behind the leaf sheath penetrate into the stalk. Our observations indicate that this is true with some very susceptible varieties. However, stalk rot may be found in fields with little leaf blight and with little or no debris on the soil.

Indications are that inoculum for stalk rot may come from below ground where previously diseased stalks are buried. Corn roots grow into the old stalk material and the fungus may invade these roots and grow into the stalk. The fungus can apparently survive several years in stalk tissue and other corn debris.

In one study at the University of Illinois, stalk rot was more severe with complete, conventional tillage than with reduced tillage. In another study, rotation with soybeans did little to control stalk rot.

Yield loss

Very little experimental evidence is available on yield losses due to anthracnose leaf blight or stalk rot. One study of the leaf blight phase of the disease indicated that 40 percent or more of the leaf tissue would have to be blighted three to four weeks after silk before yield would be reduced. Early blighting of leaves could affect yields but blighting late in the growing season would have little if any effect. In most years, anthracnose leaf blight develops late in the growing season and yield loss is thought to be minor.

Yield loss due to stalk rot may follow premature killing or lodging or both. Estimates of losses vary greatly, depending on location, genotype, and experimental methods.

In one study, fungus spores were injected into the stalks of three hybrids at silk and at two, four, and six weeks after silk. Yield reductions due to premature death ranged from 0 to 40 percent depending on the genotype and time of inoculation. The only hybrid with a significant yield loss had the susceptible inbred C123 as one parent.

In another study, yield loss due to stalk rot was estimated by comparing healthy and diseased plants of 36 hybrids. About 25 percent of the plants in the study area were diseased. Average grain weight reduction was 9.5 percent per diseased plant.

As of yet, no estimates of loss due to stalk lodging have been made. However, in several recent years, particularly 1977, stalk rot has caused severe lodging in some areas.

Control

Recommendations for control of anthracnose often include crop rotation and plowing under crop debris. However, little experimental evidence is available on the value of either method. Both methods could reduce the amount of early leaf blight infection, but they do not appear to be very effective in years of abundant rainfall and extended periods of cloudy weather. According to preliminary studies, neither method controls stalk rot.

The best control methods are to avoid very susceptible genotypes and to breed for disease resistance. At present, the extremely susceptible inbreds and hybrids have been identified and are not widely used where anthracnose is a problem. Other susceptible hybrids are being used because they may have higher yield potentials, even in the presence of disease, than more resistant hybrids.

Less is known about inheritance of resistance in corn to *C. graminicola* than to many other corn pathogens. A number of studies are being done at the University of Illinois to identify sources of resistance and to upgrade populations which may serve as sources of future inbred lines.

According to results from several experiments, resistance to leaf blight is not very highly correlated with resistance to stalk rot. Different genetic systems appear to be involved in determining resistance to the two phases of the disease. Moreover, resistance to stalk rot caused by *C. graminicola* is not highly correlated with resistance to other stalk rot organisms.

Resistance to anthracnose leaf blight and stalk rot has been found in corn seedlings as well as in mature plants. Scientists at university experiment stations and commercial seed companies are working to utilize these sources of resistance in hybrids.

Breeding for anthracnose resistance has been successful with broomcorn and grain sorghum and indications are that it will be successful with corn. In the future, we hope that high-yielding resistant hybrids will be readily available.

Urbanites Go Back to the Farm

FREDERICK C. FLIEGEL, JAMES D. WILLIAMS, and ANDREW J. SOFRANKO

SINCE AT LEAST the early 1970's, a new trend in population movements has been observed throughout the nation: For the first time in recent history, more people are moving from cities to rural areas than the other way around. Many quite remote rural areas are gaining population after decades of loss.

Press accounts of city people searching out old farm houses suggest a nostalgic quest for some of the amenities of rural life. Typically, such stories do not imply an interest in working the land, except possibly as a hobby and on a very small scale. Some reports, however, refer to homesteading and the joys of being one's own boss on the land rather than chained to a desk. Our immediate concern is the extent to which farming, as distinct from small town or rural residence, is attracting urbanites to the country.

Locating urban migrants

This article covers a small part of an extensive study of migration to rural areas. In preparing for the larger study, we examined Census reports to assess population trends for the 866 rural (nonmetropolitan) counties in the 12 states that comprise the North Central region.

That exercise resulted in identifying 75 counties that had experienced net in-migration of at least 10 percent from 1970 to 1975. Many of the counties are distant from major metropolitan centers. For example, the Illinois counties in the sample are at the southern tip of the state. Other rapidly growing counties are in the Missouri Ozarks and the "cut-over" areas of Minnesota, Wisconsin, and Michigan. Most of these areas were population losers in the not-so-distant past.

A listing of all households in the 75 counties was formulated from telephone subscriptions. Systematic samples were drawn from this list. Screening questions over the telephone in late 1976 and early 1977 permitted us to firmly identify 510 households that had in-migrated from metropolitan areas since 1970. Members of these households were later interviewed in more detail. Samples of permanent residents and migrants from other rural areas were also interviewed for purposes of comparison.

Life in the country

One in every five (22.2 percent) of our metropolitan migrants reported living on a farm when interviewed. Another 42.9 percent were living in open country nonfarm settings, making a total of almost two-thirds who had opted for country life. In contrast, only about half of the recent migrants from other rural areas and the long-term residents were living in the country.

Our respondents of metropolitan origin were much more likely to cite quality of life reasons for moving than is typical of migrants studied in the past. Historically, jobs and other economic considerations have been the major reasons for migration. The current urban-to-rural trend is new not only in change of direction, then, but also in the motivating forces behind the trend.

Urbanites as farmers

Living in the country or on a farm is still a long step from active involvement in agriculture. Only about one-third of those residing on farms reported raising some products for sale in 1976, and we now turn to these "farmers," using that term in its broadest sense.

At this point we are dealing with only 31 of our original sample of 510 metropolitan migrants. These households are not only a small fraction of the total migrant stream but are too few in number to permit much generalization. Nevertheless, we feel strongly that they can provide a clearer perspective on urbanites' involvement in agriculture than the purely anecdotal accounts available thus far.

First, let us identify the urban migrant as part of the total farm population in the growth counties. Our best guess, based on estimating total population figures from sampling fractions, indicates that roughly every eleventh or twelfth farm resident is a recent migrant from metropolitan areas. Similarly, we estimate that every fifteenth or sixteenth producer of any farm products for sale in these counties is a recent urban migrant. One can argue, then, that the metropolitan migrants represent a small but noteworthy addition to the farm population of the 75 counties. We do not know how many farmers moved out of the counties during the period, so we cannot estimate net impact. However, since farm population is declining nationwide, any movement into agriculture deserves some attention.

Second, who are these urban farmers? We had not expected it, but two of them are actually career farmers, and urbanites by definition only (Table 1). They had been farming in metropolitan areas, presumably on the fringes. Both currently depend on farming for a substantial proportion of total income. Since they are urbanites only in a technical sense, we will not describe them further.

A desire to return to the land is often cited in discussions of the population turnaround. Nine of the 31 urban migrants (29 percent) grew

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up on a farm, lived in a city for some years, and then went back to farming. In general, they are middle-aged and have farms of substantial size but, as we discuss later, most of them are only nominally returning to farming.

The largest fraction of our sub-sample, 65 percent (20 cases), are not truly returning to the land for they have no prior farm experience. These "recruits" to farming are younger than the others we have described and have much smaller farms. Average farm size alone suggests that commercial farming is not what these urbanites are seeking, but there are exceptions here, too, as we will point out later.

Back to the land

Given the perils of the agricultural ladder in an age of high capital investment in farming, it is not unusual for young would-be farmers to seek off-farm jobs in order eventually to break into farming. However, our information suggests that only three of the nine returnees identified in Table 1 left city jobs and are now substantially involved in agriculture.

Two of the returnees are retired persons, neither of whom obtained more than 20 percent of 1976 income from farming. The other four are residential or hobby farmers, with holdings ranging from 46 to 80 acres. Only one of the four obtained as much as one-third of his 1976 income from farming, and all hold off-farm jobs. Thus, six of these nine returnees to the land clearly depend on the town and village economy of the growth counties for most of their income, but they are also part of the small and part-time sector of American agriculture.

Of the three returnees who seem to fit the agricultural ladder concept, not one gave farming as his principal occupation. Two of them have large holdings — 1,200 and 2,000 acres — but only the third, with 120 acres, depended on farming for more than half of 1976 family income. These are not necessarily small farmers, then, but they are part-time.

Recruits to farming

The first impression of returnees to agriculture (Table 1) suggested a fairly serious commitment to agriculture, which proved on closer inspection to be accurate for only a few. Similarly, the first impression of the recruits, from Table 1, as primarily small-scale, hobby farmers is also misleading.

Six of the 20 recruits give farming as their principal occupation. They identify with agriculture, their holdings range from 120 to 400 acres, and most of them are heavily dependent on farming for their incomes. There is a small core of urbanites here, mostly in their 40's, with about two years of college training, who seem to be quite serious about farming.

The other 14 recruits are much like most of the returnees. Four are retired and do little farming. The remaining ten are evenly split between hobby farmers, who produce very little for sale, and part-time farmers, who produce somewhat more for sale. These ten are mostly in their 20's and 30's, again have about two years of college on the average, and hold off-farm jobs as a major source of income.

Table 1. — Overview of Urban Migrants Now in Farming (31 Households)

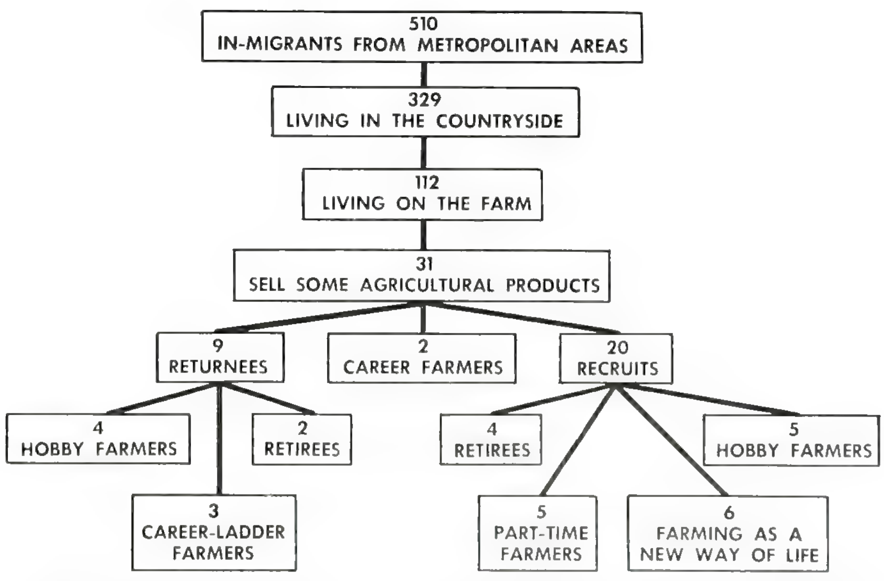
Types of urban farmers	Pct. of sample	Median age	Av. A. farmed
Career farmers	6 (2 cases)	50	375
Returnees[a]	29 (9 cases)	45	418
Recruits[b]	65 (20 cases)	40	129

[a] Urbanites raised on a farm.
[b] Urbanites with no prior farm experience.

A continuing trend?

Our description of urbanites in agriculture reflects the diversity of the rural population as a whole. Figure 1 summarizes our findings: Starting with 510 households that had migrated from metropolitan areas, we found most living in the countryside, many on farms, and finally, 31 raising some products for sale. Of these 31, six were "recruits" who had adopted farming as a way of life. They represent a small, but noteworthy new element in the agriculture of this region's most actively growing counties.

Migration into rural areas is a new trend now, but over the years it may quite possibly bring about a renaissance for both the countryside and the small town.



Starting with 510 in-migrants from urban areas into 75 rural counties, we find 31 who are selling some agricultural crops, including two career farmers and six "recruits" to agriculture whose principal occupation is farming. (Fig. 1)

A one-way valve keeps oxygen from entering this ***in vitro*** artificial rumen. Microorganisms are active in the dark layer just below the cork. Bottom layer has been solubilized. (Fig. 1)

Improving Nutritive Value Of Agricultural Residues

GEORGE C. FAHEY, JR., S. S. MASTERS, and B. L. MILLER

WITH THE WORLD'S rapidly growing population, grains in the future may have to be diverted from the feeding of ruminants to the feeding of humans and non-ruminant animals. If this happens, straw, sawdust, hulls, stalks, and other fibrous residues will become more and more important in ruminant rations. Fortunately, the ruminant animal can digest such materials while other species cannot.

If ruminants are to get the most benefit from low-quality residues, these materials must be treated chemically or mechanically to break down their fibrous structure. This will allow the microbial population of the rumen to more easily attack the carbohydrate moieties of the plant.

It has generally been found that ruminants can digest chopped forages more easily than finely ground and pelleted forages. In other research, treating forages and wood materials with sodium hydroxide has significantly improved the digestibility of these materials.

In our experimental work, we have treated cornstalks and soybean residues with a variety of chemical reagents in an attempt to break down their fibrous matrix and improve their nutritive value.

In vitro trials

Various chemical treatments were tested on forage samples by using an *in vitro* (in the test tube) technique for simulating a ruminant's digestive processes. In the initial stage of the *in vitro* system, a roughage sample is incubated with rumen microorganisms in a buffered nutrient solution. Under anaerobic conditions of controlled temperature and pH, the microorganisms produce enzymes that break down structural carbohydrate components into soluble components, much as they would in the rumen (Fig. 1).

In the second stage, the residue from the first stage is incubated in a hydrochloric acid-pepsin solution. This stage simulates the breakdown of proteins by the enzyme pepsin in the lower gastrointestinal tract of the animal.

The amount of organic matter that disappears *in vitro* is closely related to that digested by the live animal (*in vivo*). *In vitro* results are expressed as the percent *in vitro* organic matter digested (IVOMD). The carbohydrate cellulose can also be measured by treating the final residue with a mixture of acetic and nitric acids. Results are expressed as the percent *in vitro* cellulose digested (IVCD).

Ensiled residues

For our first experiments, we ensiled cornstalks and soybean residues in Mason jars at two moisture levels — 50 percent and 60 percent. When ensiling the residues, we added a variety of chemical reagents at the 2 percent level on a moist basis. After 30 days, the ensiled roughages were dried, ground, and used as substrates in IVOMD and IVCD determinations.

At the 50 percent moisture level, none of the experimental reagents significantly affected cellulose digestibility (Table 1). The only significant improvement in organic matter digestibility resulted from the addition of propionate to cornstalks.

At the 60 percent moisture level, wood molasses depressed the digestibility of cornstalk cellulose. None of the other ingredients significantly affected the digestibility of cellulose in either cornstalks or soybean residues. However, sodium chlorite significantly improved the digestion of organic matter in both roughages, and ammonium hydroxide and propionate improved organic matter digestibility of the soybean residues.

Differences in digestion as affected by moisture content at ensiling are shown in Table 1. Even without any treatment, cornstalks ensiled at 60 percent moisture had significantly higher cellulose digestion than those ensiled at 50 percent moisture. Cellulose digestion was also significantly higher at the 60 percent level for cornstalks treated with ammonium hydroxide and wood molasses; and for soybean residues treated with sodium chlorite, propionate, and wood molasses.

Organic matter digestibility was affected quite differently. For cornstalks, all IVOMD values were higher at the 50 percent moisture level than the 60 percent level, with the difference being significant for the propionate-treated stalks. Soybean residues showed reverse trends.

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Residues treated with sodium chlorite and propionate were significantly higher in IVOMD at the 60 percent level.

Unensiled residues

In the second phase of our work, we treated unensiled cornstalks and soybean residues with various chemicals. Our purpose was to improve digestibility either by disrupting the bonding between polysaccharides or by extracting compounds that inhibit the animal's ability to digest the plant material.

The three primary polysaccharides found in roughages are cellulose, hemicellulose, and lignin. Dioxane is a reagent which, when mixed with hydrochloric acid, can break the chemical bonds between these three polysaccharides. Three concentrations of this reagent were tried with 1.2 percent hydrochloric acid as the dispersing solvent. Thirty grams of either cornstalks or soybean residues were mixed with 500 milliliters of each dioxane treatment and allowed to react for 24 hours. The samples were then filtered, washed, dried, and ground to serve as substrates for *in vitro* experiments.

Cellulose digestion of both roughages was significantly improved with all concentrations of dioxane and hydrochloric acid (Table 2). However, results were just as good with hydrochloric acid alone. It thus appears that dioxane does not enhance cellulose digestion in low-quality roughages.

Recent work suggests that phenolic compounds in the plant can interfere with the ruminant's digestion of carbohydrates. We therefore tried treating the residues with polyvinylpyrrolidone (PVP), a reagent with the ability to adsorb phenolic compounds. Three solutions of PVP — 2.5, 5, and 10 percent — were added to cornstalks or soybean residues at the rate of 500 milliliters to 40 grams. After 24 hours, the samples were filtered, washed, dried, ground, and used as substrates for cellulose digestion determinations. As shown in Table 2, PVP had no effect on the cellulose digestion of either roughage.

Purified fractions of fiber were also isolated from both roughages. The neutral detergent fiber fractions contain a combination of cellulose, hemicellulose, and lignin. The acid detergent fiber fractions contain cellulose and lignin, whereas the holocellulose fractions contain cellulose and hemicellulose with no interfering lignin.

All these fractions were evaluated with the *in vitro* method and the results are presented in Table 2. Cellulose digestion was much higher in the holocellulose of both roughages than in the untreated samples. It was also significantly higher in the neutral detergent fiber of cornstalks than in the untreated control, but it was not improved in the neutral detergent fiber of soybean residues. IVCD was significantly depressed in the acid detergent fiber fractions of both roughages.

Table 2. — Cellulose Digestibilities of Unensiled, Chemically Treated Cornstalks and Soybean Residues

Treatment	IVCD, %	
	Cornstalks	Soybean residues
Untreated	26.3[a]	34.7[a]
2.5% dioxane in HCl	34.4[b]	52.0[b]
5.0% dioxane in HCl	31.9[b]	51.6[b]
10.0% dioxane in HCl	33.5[b]	54.9[b]
1.2% HCl	33.3[b]	54.4[b]
2.5% polyvinylpyrrolidone	25.5[a]	28.3[a]
5% polyvinylpyrrolidone	27.1[a]	30.0[a]
10% polyvinylpyrrolidone	27.3[a]	29.5[a]
Neutral detergent fiber (C+H+L)*	38.9[b]	34.2[a]
Acid detergent fiber (C+L)*	4.4[c]	10.6[b]
Holocellulose (C+H)*	54.3[d]	61.9[c]

[a,b,c,d] Numbers in the same column bearing different superscript letters differ significantly.
* C = cellulose; H = hemicellulose; L = lignin.

Conclusions

On the basis of our results, chemical treatment of ensiled cornstalks and soybean residue can improve *in vitro* organic matter digestibility but has little effect on *in vitro* cellulose digestion. There is also some evidence of interactions among moisture content of roughages at ensiling and type of roughage used. Future work will possibly reveal that a combination of additives at ensiling can improve the overall utilization of low-quality agricultural residues.

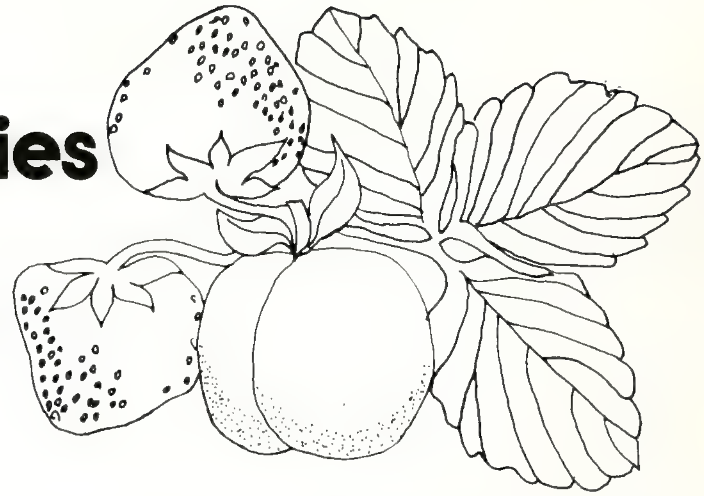
Treatment of unensiled low-quality residues appears to be of limited value. While some plant fiber fractions were digested more completely than the untreated controls, it is not practical to prepare these fractions for feeding to ruminant animals. Reagents that theoretically should exhibit some potential for improving the nutritive value of plant material did not prove to be effective for the two residues studied here.

Table 1. — Cellulose and Organic Matter Digestibilities of Treated Cornstalks and Soybean Residues Ensiled at 50 Percent and 60 Percent Moisture

Roughage and treatment	50% moisture		60% moisture		Difference (60% values less 50% values)	
	IVCD,%	IVOMD,%	IVCD,%	IVOMD,%	IVCD,%	IVOMD,%
Cornstalks						
Control (ensiled)	27.3[a]	21.5[a]	34.5[a]	18.6[a]	7.2*	−2.9
Control (not ensiled)	13.6[b]	17.9[a]	13.6[b]	13.6[a]	...	...
Sodium chlorite	35.5[a]	26.2[a]	34.7[a]	25.3[b]	−0.8	−0.9
Ammonium hydroxide	25.5[a]	26.1[a]	32.5[a]	20.6[a]	7.0*	−5.5
Propionate	31.1[a]	32.3[b]	37.6[a]	19.9[a]	6.5	−12.4*
Wood molasses	18.6[a]	22.0[a]	27.3[c]	18.1[a]	8.7*	−3.9
Soybean residues						
Control (ensiled)	38.4[a]	24.8[a]	42.9[a]	27.1[a]	4.5	2.3
Control (not ensiled)	37.3[a]	28.4[a]	37.3[a]	28.4[a]	...	...
Sodium chlorite	37.1[a]	27.8[a]	47.4[a]	35.6[b]	10.3*	7.8*
Ammonium hydroxide	45.8[a]	28.4[a]	43.8[a]	32.0[b]	2.0	3.6
Propionate	32.9[a]	26.3[a]	44.1[a]	33.4[b]	11.2*	7.1*
Wood molasses	35.8[a]	30.7[a]	44.3[a]	30.1[a]	8.5*	−0.6

[a,b,c] Numbers in the same column bearing different superscript letters differ significantly.
* Significantly different ($P < 0.05$).

Frozen Strawberries and Peaches:



How Different Packing Methods Affect Palatability and Ascorbic Acid Content

Wen-Nan Wang and Frances O. Van Duyne

RECOMMENDATIONS for freezing fruit abound, and the general principles involved in the selection and preparation of fruit are well established. However, there is little agreement about the specifics of the packing procedures — ratio of sugar to fruit, concentration of sugar sirup, and exact amounts of ascorbic acid to add — that will give the most desirable products after freezing and freezer storage.

A further complication is that many consumers have become interested in freezing fruit without sugar or sugar sirup in order to reduce sugar consumption or caloric intake. Packing in water has been used not only to eliminate sugar but also to decrease contact of the fruit with air, and the addition of ascorbic acid has been proposed to improve quality.

Purpose and methods of study

In view of these new trends, we froze strawberries and peaches in water with both low and high concentrations of ascorbic acid. The purpose was to determine the effects of these treatments on the palatability and ascorbic acid retention of the fruits. Other packs were prepared from the same lots of fruit and included in the comparisons.

The low level of ascorbic acid was 0.08 percent; the higher level, 0.32 percent. In Illinois Extension Circular 602, *How to Prepare Fruits and Vegetables for Freezing*, we recommend packing light-colored fruits in sugar sirup with about 0.08 percent ascorbic acid. Other researchers, however, have suggested using higher concentrations, particularly when fruits are packed in water.

Whole, dehulled Red Chief strawberries were frozen plain; covered with 40 percent sugar sirup; in water containing the 0.08-percent concentration of ascorbic acid; and in water containing the 0.32-percent concentration of ascorbic acid.

Peeled, sliced Redhaven peaches were frozen in 40-percent sugar sirup; in 40-percent sugar sirup containing the lower concentration of ascorbic acid; and in water with the lower and higher concentrations of ascorbic acid. Four replications of each set of treatments were prepared and tested after four periods of freezer storage.

Frozen strawberries were thawed and tested after 1 day and after 1, 4 and 8 months of freezer storage; thawed peaches, after 1 day, 6 weeks, and 4 and 8 months. Drained weights of the fruit and the liquids were recorded. The reduced ascorbic acid content of fresh and thawed frozen fruit and the drained liquids was determined by a chemical method.

Six members of the food research staff scored the samples for appearance, color, texture, flavor, and absence of off-flavor. The palatability factors were rated on a 5-point basis with 5 corresponding to the most desirable descriptive term and 1 to the least desirable. Total scores were obtained by adding the scores for the individual factors.

Drained weights

After each storage period, drained strawberries packed in 40-percent sugar sirup weighed more than berries packed plain or in the two ascorbic acid solutions. However, even the sirup-packed strawberries lost some of their fresh weight during freezing and freezer storage.

Drained weights of the peaches packed in sugar sirup or in sugar sirup with added ascorbic acid were similar and slightly higher than the original weights. Peaches packed in water with added ascorbic acid lost only small amounts of weight during freezing and freezer storage.

Ascorbic acid content

The reduced ascorbic acid content of the four replications of fresh strawberries ranged from 0.45 to 0.50 milligram per gram and of peaches from 0.06 to 0.08 milligram per gram. There was some indication that strawberries held 2 days after picking contained less ascorbic acid than did those analyzed and processed after 1 day. The third and fourth replications of peaches appeared to have lower ascorbic acid contents than the first two, which had been harvested 1 or 2 weeks earlier.

After freezing and freezer storage, the amounts of reduced ascorbic acid in strawberries differed significantly due to replications, treatments, and length of freezer storage (Table 1).

Drained berries that had been packed in water with the higher level of ascorbic acid contained the greatest concentrations of ascorbic acid; berries packed in water with the lower level of ascorbic acid ranked second. Berries packed plain or in sugar sirup contained less ascorbic

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acid than the fresh berries, but the data indicate that sugar sirup provided some protection for the amounts originally present. In all packs the amounts in the drained berries decreased between 1 day and 8 months of freezer storage.

After 1 day of freezer storage, juice from the plain-packed strawberries contained more ascorbic acid than did that from the sirup-packed berries. However, as storage time increased, ascorbic acid content declined in the liquids from the plain-packed berries and increased in those from the sirup packs.

As expected, there were greater amounts of ascorbic acid in the drained liquids from the berries packed in ascorbic acid solutions but, in general, these decreased as storage time increased.

Drained peach slices packed in the higher concentration of ascorbic acid in water contained the greatest amounts of ascorbic acid (Table 2). Those prepared with the lower concentration of ascorbic acid, whether packed in water or in sugar sirup, were similar to one another in ascorbic acid content. Peaches packed in plain sugar sirup contained very little ascorbic acid.

When we calculated total percent retentions of ascorbic acid based on the amounts present in the drained solids and liquids, we found no consistent trends with increasing storage in any of the packs.

Table 1. — Thawed Frozen Strawberries: Mean Ascorbic Acid Contents and Mean Total Palatability Scores

Storage period	Type of pack			
	Plain	40% sugar sirup	0.32% ascorbic acid in water	0.08% ascorbic acid in water
Ascorbic acid, mg./gm.[a]				
1 day	0.33 ± 0.009	0.37 ± 0.012	1.48 ± 0.114	0.60 ± 0.014
1 month	0.27 ± 0.040	0.34 ± 0.026	1.43 ± 0.023	0.58 ± 0.028
4 months	0.26 ± 0.039	0.27 ± 0.025	1.49 ± 0.027	0.55 ± 0.007
8 months	0.20 ± 0.030	0.23 ± 0.037	1.42 ± 0.049	0.53 ± 0.020
Total palatability scores[a,b]				
1 day	17.8 ± 0.35	20.5 ± 0.31	18.9 ± 0.27	18.8 ± 0.32
1 month	17.9 ± 0.30	19.7 ± 0.27	17.4 ± 0.39	17.5 ± 0.32
4 months	17.0 ± 0.44	19.0 ± 0.46	16.7 ± 0.37	16.6 ± 0.51
8 months	15.0 ± 0.50	17.9 ± 0.34	15.1 ± 0.36	15.4 ± 0.47

[a] Means and standard deviations of the means.
[b] Highest possible total score is 25.

Table 2. — Thawed Frozen Peaches: Mean Ascorbic Acid Contents and Mean Total Palatability Scores

Storage period	Type of pack			
	40% sugar sirup	0.08% ascorbic acid in 40% sugar sirup	0.32% ascorbic acid in water	0.08% ascorbic acid in water
Ascorbic acid, mg./gm.[a]				
1 day	0.02 ± 0.005	0.16 ± 0.016	1.13 ± 0.049	0.17 ± 0.010
6 weeks	0.01 ± 0.003	0.17 ± 0.014	1.14 ± 0.074	0.18 ± 0.011
4 months	0.02 ± 0.001	0.18 ± 0.001	1.34 ± 0.040	0.23 ± 0.008
8 months	0.01 ± 0.002	0.19 ± 0.010	1.22 ± 0.017	0.18 ± 0.010
Total palatability scores[a,b]				
1 day	20.6 ± 0.24	20.5 ± 0.28	18.7 ± 0.33	19.0 ± 0.28
6 weeks	19.8 ± 0.39	19.8 ± 0.44	17.5 ± 0.44	17.0 ± 0.48
4 months	19.8 ± 0.25	19.6 ± 0.24	16.8 ± 0.44	17.0 ± 0.43
8 months	18.9 ± 0.38	18.7 ± 0.26	16.2 ± 0.35	16.0 ± 0.31

[a] Means and standard deviations of the means.
[b] Highest possible total score is 25.

Palatability of thawed frozen fruit

Mean total palatability scores for thawed, drained strawberries differed significantly with treatment and storage period (Table 1). Sirup-packed strawberries had the highest total scores, because they scored higher in appearance, flavor, and absence of off-flavor than did berries prepared in other ways. Mean scores for berries packed plain or in water were similar to one another. As storage time increased, scores for the individual palatability characteristics and the total scores usually decreased, regardless of the type of pack.

The mean scores for appearance, color, texture, flavor, absence of off-flavor, and the mean total scores for drained thawed peach slices differed significantly with treatment and storage (Table 2). After each period of freezer storage, the mean total scores were always highest for peaches packed in sugar sirup with or without ascorbic acid. Peaches packed in water and the two levels of ascorbic acid consistently rated lower than the sirup-packed peaches in appearance, texture, and flavor — which accounted for the lower total scores of the water-packed fruit. The mean total scores for all the peaches were lower after 8 months of freezer storage than after 1 day.

Sugar sirup best

The palatability data support previous recommendations for freezing strawberries and peaches in sugar sirup to obtain high-quality thawed fruit. The addition of ascorbic acid increased the amounts of this nutrient in the drained fruit, with the higher concentration increasing the amounts more than the lower. However, none of the mean scores for thawed Red Chief strawberries or Redhaven peaches indicated any advantage for palatability in using a 0.32-percent solution of ascorbic acid in water rather than a 0.08-percent solution.

Energy and Protein Needs Of Lactating Dairy Cows

J. H. CLARK and C. L. DAVIS

PROPER FEEDING of the dairy herd is of utmost importance in a successful dairy operation. The nutritional factors most likely to limit milk production are shortages of energy and protein. Requirements for these nutrients depend largely on milk yield, its composition, and the cow's body weight, with milk yield having by far the greatest influence.

Early lactation critical

A properly balanced ration is especially important during the time between calving and peak milk production. This is the most critical period in the life of the dairy cow. A shortage of energy, protein, vitamins, or minerals or an imbalance in their supply may subject the cow to nutritional stress resulting in metabolic disorders or decreased production.

Feeding the high-producing cow in early lactation presents a special problem. Often she either does not receive or cannot consume enough feed to supply the energy and protein needed for maximal milk production.

When the cow's intake of energy and protein is inadequate for milk production, she will make up for this deficiency by drawing on her body stores of fat and protein. Although it is normal for high-producing cows to lose body weight in early lactation, the energy and protein available from body stores can produce only a limited amount of milk. If the cow has to rely too heavily upon body reserves of these nutrients, she must gear her production to the level of nutrient availability or succumb to a metabolic disorder such as ketosis or milk fever.

J. H. Clark is associate professor of nutrition and C. L. Davis, professor of nutrition, Department of Dairy Science.

High peak yield important

Feeding and management practices during a dairy cow's dry period and especially during the first weeks of lactation can greatly influence the peak yield of milk. Peak yield in turn affects total yield during a lactation.

The relationship between peak yield and total yield was demonstrated in a recent study at the University of Illinois (Fig. 1). Cows fed a diet containing 13.5-14.5 percent crude protein peaked at 75 pounds of milk per day and produced over 17,000 pounds of milk per cow in a 310-day lactation. Cows receiving a diet containing 11-12 percent crude protein peaked at 65 pounds of milk daily and produced about 3,800 pounds less milk. The peak milk production for cows on a diet with 9-10 percent crude protein was 60 pounds and average production per cow was about 6,000 pounds below that for the highest producing cows. Thus, any nutrient deficiency that decreases peak milk yield also greatly reduces total yield during the lactation.

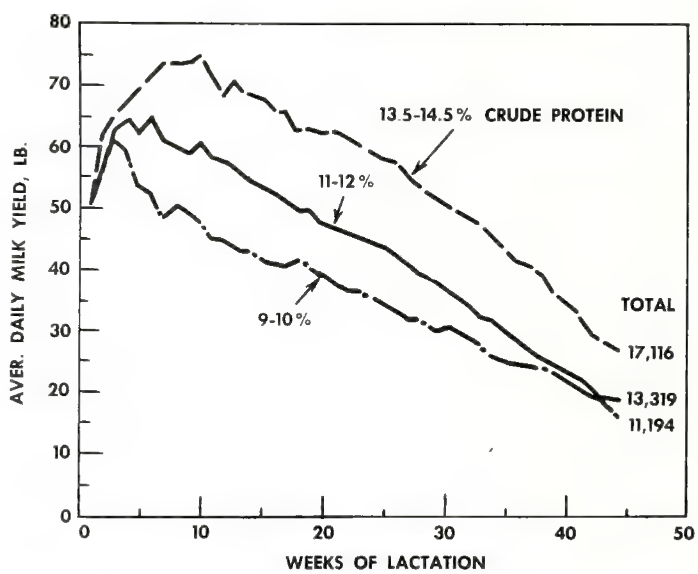
Energy

For maximum feed intake and the highest peak milk yield, the diet should be high in energy but should contain enough fiber to assure normal rumen fermentation and milk fat percentage. In general, cows will consume more energy if the dry matter in the diet consists of 55-60 percent grain and 40-45 percent good quality forage.

According to recent studies at the University of Illinois, cows producing 85 to 90 pounds of milk per day will consume dry matter at an average rate of 3.8 percent of body weight when it is supplied as 55 percent concentrate and 45 percent forage (Table 1). As the proportion of grain in the diet is increased above 60 percent, the risks of the cow going off feed or having a low milk fat percentage are increased.

Crude protein

Requirements for protein, minerals, and vitamins are closely linked to the amount of energy consumed



Effect of peak milk yield on total milk yield per lactation, three groups of 10 cows each. (Fig. 1)

by the cow. Therefore, the percentage of protein needed in the diet should be calculated on the basis of the cow's total feed consumption.

In complete lactation studies conducted during recent years, milk production increased as crude protein in the diet was increased from about 9 percent to about 16 percent. Short-term studies with high-producing cows in early lactation indicated that cows fed diets containing 18 to 20 percent crude protein produced more milk than those fed less crude protein. In other trials, cows were in the last half of lactation and were averaging 45 to 50 pounds of milk daily. They produced as well on a diet containing 11 percent crude protein as on one containing 12 to 14 percent.

Results of these trials suggest that crude protein requirements depend on the level of milk production and stage of lactation as well as total feed intake.

The most profitable level of crude protein feeding may be below the level that gives maximum milk production and may vary from place to place or year to year depending on the prices of protein supplement and of milk. Crude protein should be fed to give maximum milk production when the cost of protein supplement is low relative to the price of milk. Under these conditions, crude protein should make up 14 to 18 percent of the total diet in early lactation. When protein is expensive, the amount of protein can be decreased but care should be taken not to underfeed the high-producing cow in early lactation.

Table 1. — Daily Dry Matter Intake by High-Producing Cows During Eighth Week of Lactation

Item	Mean	Range
Body weight, lb.....	1,311	1,139-1,535
Daily milk, lb.......	87	79-110
305-day milk, lb....	19,209	16,097-25,421
Dry matter intake, lb./day.........	50	44-61
Concentrate intake, % of dry matter..	55.3	46.1-63.2
Dry matter intake, % of body weight	3.8	3.0-4.6

Table 2. — Effect of Crude Protein Level and Source of Supplemental Nitrogen on Yield of 4-Percent Fat-Corrected Milk (FCM)

Pct. crude protein in ration	Source of supplemental N	4-pct. FCM yield in 310 days, lb.
9-10.....	None	10,284
11-12.....	Urea	13,073
11-12.....	Soybean meal	12,808
13-14.....	Urea + soybean meal	14,304
13-14.....	Soybean meal	15,443

Nonprotein nitrogen

Urea is the most widely used nonprotein nitrogen (NPN) compound, and appears to produce as good a response as any that are commercially available. The only reason for feeding urea instead of natural protein is the economic advantage, if any. If 1 pound of urea and 6 pounds of shelled corn are cheaper than 7 pounds of soybean meal, then it is economical to feed urea provided the recommendations for its use are followed.

Urea adds only nitrogen to the diet. If rumen bacteria do not use this nitrogen for protein synthesis, it is of no benefit to the animal and represents a waste form of nitrogen that is excreted in the urine. In contrast, natural nitrogen sources such as soybean meal supply protein, energy, and minerals to the lactating dairy cow.

Fifty lactating cows were used in a University of Illinois comparison of urea and soybean meal as supplemental nitrogen sources. From 2 weeks before calving until 3 weeks after calving, all cows were fed a diet that was supplemented with both urea and soybean meal and contained 13 to 14 percent crude protein. On day 22 after calving, 10 cows were switched to each of five diets (Table 2).

Cows receiving a diet that contained 9-10 percent crude protein and no supplemental nitrogen produced 10,284 pounds of 4-percent fat-corrected milk (FCM) in a 310-day lactation. The 4-percent FCM production rose to about 13,000 pounds when the crude protein level was increased to 11-12 percent by supplementation with either urea or soybean meal; there was no significant difference between the two sources of nitrogen.

A further rise in 4-percent FCM production resulted from adding urea and soybean meal to raise the crude protein level to 13-14 percent. However, the increase in milk production was even greater at this same crude protein level when soybean meal was fed as the only source of supplemental nitrogen.

These results suggest that urea is used most efficiently when small quantities are added to low-protein, high-energy diets. Efficiency of utilization decreases as (1) the amount of urea in the diet increases, (2) crude protein increases, and (3) energy content decreases.

Feeding recommendations

During early lactation high-producing cows should be fed all the energy they will consume. Diets should contain 14 to 16 percent crude protein depending on the cost of the protein and the level of milk production. When protein prices are low, high-producing cows may receive as much as 18 to 20 percent crude protein in their diets. After peak milk yield, when production drops to 40-50 pounds, crude protein can be decreased to 12 or 13 percent without reducing milk production.

NPN should not be included in diets that contain more than 13 percent crude protein. It can supply part of the crude protein after peak milk yield, when production declines below 50 pounds per day. NPN can be added to either the concentrate mixture or corn silage. If urea is the NPN source, it should not exceed 1.5 percent of the concentrate mixture. When included in corn silage, urea should be added at the time of ensiling, at the rate of 10 pounds per ton of silage. Urea should be thoroughly mixed with dietary ingredients before feeding because too much urea can cause ammonia toxicity resulting in death.

Low-Income Families Receive Personalized Consumer Education

JANE A. SCHERER

Gladys Vasquez of Chicago works for the Illinois Cooperative Extension Service as a special kind of employee. She is a program assistant with the Consumer and Homemaking Education Program (CHEP), a unique program designed to help low-income families improve their use and management of available resources.

Recently she started a typical day by meeting with five Spanish-speaking homemakers in a tenement house. The homemakers had all been plagued with rats — one rat had bitten off the tip of a sleeping baby's finger. The homemakers had called the sanitation department, but nothing had improved. That's when Gladys suggested a group meeting in one of the apartments. The landlady and her husband attended too.

After Gladys showed slides on ways to keep rats out of buildings, the landlady and the tenants began talking about the problem and possible solutions. The landlady's husband agreed to patch up any holes where rats could enter, now that he had seen how to do it. And the tenants agreed to do their part by putting food away and disposing of garbage.

Next, Gladys visited a homemaker whose child had been accidentally poisoned. Her husband had mixed roach killer in a plastic milk container and put it in the refrigerator. Their six-year-old son, who was home alone, went for a glass of milk and instead drank roach killer. The mother arrived home just in time to get him to the hospital. Gladys showed the woman how to store poisons safely so that the accident would not be repeated. She showed slides, left literature, and put a sticker on the telephone listing emergency numbers to call for help.

Her third visit was to a Mexican woman who complained because her seven children were not taking care of their clothing. Not knowing how to remove stains and wash garments, the woman simply threw the clothes away. Gladys taught her how to remove stains and planned further visits for teaching the woman how to wash and mend the clothes.

Her last visit for the day was to a 28-year-old homemaker who had a three-year-old son. The homemaker said he was a "bad boy" and habitually stepped on his hands for punishment. Gladys explained some reasons for children's misbehavior and gave the homemaker a pamphlet about the importance of developing self-respect in children.

CHEP's scope

CHEP was established in 1971 with funds from a contract with the Illinois Office of Education, Department of Adult, Vocational and Technical Education. These funds became available through the Vocational Education Act of 1968.

The program has operated in 15 Illinois counties where significant numbers of low-income families live. It has reached over 13,000 homemakers by one-to-one teaching, modeled after the approach used in the Extension Service's Expanded Food and Nutrition Program.

The Extension philosophy of helping people help themselves is well exemplified in the program's objectives. CHEP strives to help families acquire the knowledge, skill, and motivation for managing family resources wisely; gain maximum satisfaction from available human and material resources; improve their competencies in the marketplace; and increase awareness of resources available to consumers in the community, state, and nation.

Program assistants

Because low-income homemakers know their own problems best, CHEP hires low-income people as paraprofessionals, or program assistants, to teach other low-income homemakers in their neighborhoods. Before starting their jobs, program assistants take part in an intensive three-week orientation. They learn about Extension and CHEP philosophy, operational procedures, and teaching skills. They are also taught subject matter to pass on to consumers and are trained to relate their information to specific family problems. After orientation is completed, program assistants continue to receive in-service education.

Their challenge is to provide families with consumer information while establishing rapport and gaining enough information about the families to help them. Program assistants encourage each family to identify a major concern and determine appropriate ways to improve the situation. It's then up to the program assistants to provide the learning experiences that will bring about the desired changes.

The home visit is the program assistant's major method of reaching families; her teaching method is show-tell-do. When several homemakers have the same problem, the program assistant brings them together so that they can help one another.

Program assistants enrol homemakers in CHEP for up to three years. When the homemakers have

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A CHEP program assistant teaches about sources of credit to a homemaker in her home. Over 3,600 Illinois homemakers are at present enrolled in CHEP.

achieved a satisfactory level of competence in consumer and homemaking skills, they graduate and are encouraged to participate in other programs conducted by the Cooperative Extension Service.

Community workers

In January, 1977, CHEP hired community workers in Madison and St. Clair Counties to help CHEP "graduates" move smoothly into other Extension programs. Community workers develop and conduct special classes for soon-to-be graduated homemakers and those who have already graduated. They also work with homemakers not reached by the Cooperative Extension Service in any other way.

Teaching materials

Special teaching materials have been developed to meet the educational needs of the homemakers enrolled in CHEP. These materials describe living situations familiar to CHEP families and are written clearly and directly in a style CHEP homemakers can readily understand.

Because a single concept must often be retaught, program assistants use several different teaching aids to get across one concept. For example, to teach about budgeting, program assistants are supplied with pamphlets, flip charts, filmstrips, worksheets, cartoons, and games. From this selection the program assistant chooses the teaching aids best suited to the needs of a particular family. So far, Extension staff members have developed over 250 pamphlets and other teaching aids for use in CHEP.

Consumer Call-In

Another way CHEP is extending its outreach is through the Consumer Call-In, a telephone information service in Chicago. It is operated by bilingual staff members who answer questions about money management, food and nutrition, textiles and clothing, family life, health, housing and home furnishings, and community resources.

The operators get their answers from a card file system, with each card giving information about a single concept. If a topic is not in the file, the operator takes the caller's name and phone number and refers the question to an Extension assistant at the University who works closely with the Extension specialists. The answer is relayed back to the consumer within 48 hours. To date the Consumer Call-In has answered over 20,000 consumer questions.

The service supplies consumer information to many more people than would ordinarily be reached through face-to-face teaching. The Consumer Call-In provides a direct link between the one-to-one teaching done by program assistants in Chicago and the traditional Extension program.

CHEP appreciated

CHEP has successfully reached out and touched thousands of low-income families who are often difficult to reach. These families experience great satisfaction from becoming increasingly competent in identifying and solving their own problems. They continually express appreciation for the opportunity to participate in the program and praise the program assistants' supportive, responsive teaching efforts.

Daisy Saez, a Spanish-speaking Consumer Call-In operator, refers to the card file to answer a consumer's question about food storage.

Cooking Alternatives for Saving Energy

MARTHA BREMER, BARBARA FARNER, and JACQUELINE ANDERSON

EACH YEAR food takes an increasing amount of our financial resources. Added to the cost of the food itself are the costs of utensils and appliances to prepare the food and of energy to operate the appliances.

The Federal Energy Administration is proposing that many appliances be made more efficient in energy usage. For example, by 1980 gas ranges must be improved by 51 percent, electric ranges by 3 percent, and microwave ranges by 5 percent. When the more efficient ranges become available, they will probably cost more than present models.

In the meanwhile, there are ways to conserve energy without buying costly new appliances. Even a small saving at each meal will add up to a sizable amount during the year.

Some energy-saving practices are suggested by results of a recent study, in which we compared the watt hours required to prepare a simple meal using a conventional range and oven; selected small appliances; and a microwave range. The meal consisted of two hamburger patties (113.2 grams or about 3.6 ounces each); frozen French-cut green beans (127.3 grams or about 4 ounces); and five refrigerator biscuits. The experiment was replicated three times.

Conventional range and oven

An 8-inch cast aluminum frypan was used to cook hamburgers on the conventional range. The frypan was preheated on the 8-inch surface unit at the medium-high setting for 3 minutes. The heat was then lowered to the medium setting and the hamburgers were cooked for 5 minutes on each side.

The green beans were cooked on a 6-inch unit. One-third cup of water was brought to a boil at the highest setting, the beans were added, and the contents were allowed to return to the boiling point. The temperature control was then reduced to the low setting and the beans were cooked for 10 minutes. Biscuits were baked for 8 minutes in an oven that had been preheated to 450° F. for 10 minutes.

Small appliances

A second alternative for preparing the meal was to use an electric frypan, an electric saucepan, and a portable oven-broiler. The frypan was preheated to 350°F. and the hamburger patties were cooked 5 minutes on each side.

The green beans and ⅓ cup of water were heated in the electric saucepan at 250°F. until the contents were boiling. The beans were stirred and allowed to return to a boil, after which the temperature setting was lowered to 225° and the beans were cooked for 10 minutes. Biscuits were baked for 8 minutes at 450° in the preheated oven-broiler.

Microwave range

A one-setting microwave range with a 600-watt output represented a third alternative. Hamburger patties were cooked 1½ minutes in a covered casserole dish, turned over, and cooked an additional 1½ minutes. Green beans were placed in a covered casserole dish, cooked 4 minutes, stirred, and cooked 4 more minutes.

Biscuits were not cooked on the microwave range because the results of previous tests had not been satisfactory.

Energy use

Energy use with the different cooking alternatives differed widely (Table 1). For cooking hamburgers, the conventional range used the most energy; the microwave range, the least. Mean watt-hours consumed by the electric frypan was 67 percent of the conventional range usage. This supports the Association of Home Appliance Manufacturers' conclusion that the electric frypan uses 10 to 70 percent less energy than a conventional range.

The microwave range was the least economical appliance for cooking green beans. It used 25 percent more energy than the electric range and almost three times as much as the electric saucepan.

Baking biscuits in the portable oven instead of the conventional oven reduced energy usage by 50 percent.

Cooking an entire meal with small appliances instead of the conventional range and oven cut energy use almost in half. The combination of microwave range and portable oven also greatly reduced energy use, but the saving was much less (11 percent) when the conventional oven was combined with the microwave range. The most economical alternative of all would be to cook hamburgers in the microwave range and the green beans and biscuits in the portable appliances.

Research is needed on the feasibility of using portable appliances as the only cooking alternative in a home.

Table 1. — Electrical Energy Use

Appliance	Hamburger patties	Green beans	Biscuits	Complete meal
	watt hours			
Conventional range-oven	213	126	653	992
Portable appliances	143	57	328	528
Microwave range & conventional oven[a]	69	160	653	882
Microwave range & portable oven[a]	69	160	328	557

[a] Biscuits were baked in either a conventional or a portable oven since a microwave range is not satisfactory for this purpose.

Martha Bremer is a former student; Barbara Farner, a graduate student; and Jacqueline Anderson, assistant professor, School of Human Resources and Family Studies.

Milk Intake Of University Students

P. S. WEATHERSBEE, J. R. LODGE, and L. K. OLSEN

MILK has long been recognized as a nearly complete food, high in protein, minerals, and vitamins. Unfortunately, Americans are tending to pass it up in favor of beverages with more calories and much less nutritional value. The annual decline in per capita milk consumption has been going on steadily for the past 20 years.

In general, milk consumption tends to be highest during childhood and the developmental years, decreasing with age of the individual. Assessing and understanding the factors that underlie this trend is important both to the dairy industry and to the nutritionist. Further information on this trend in consumption was obtained through a recent survey of college students' beverage consumption.

How study was conducted

The survey, which was part of a larger study, was conducted at the University of Illinois, Southern Illinois University, University of Nebraska, and Brigham Young University. A questionnaire was self-administered to approximately equal groups of students on the four campuses. It contained 53 items and was designed to determine the type, frequency, and level of consumption of a wide variety of beverages.

Of the 989 students in the study, 54.2 percent were women and 45.8 percent were men. The participants were evenly distributed by both age (Table 1) and year in school. With the exception of the students from Brigham Young University, who are predominantly Mormon, the religions of the students were heterogeneous while still reflecting the religious makeup of their campuses.

P. S. Weathersbee is a graduate research assistant and J. R. Lodge, professor of physiology, Department of Dairy Science. L. K. Olsen was formerly associate professor, Department of Health and Safety Education.

Trends in consumption

A majority of both the men (94.9 percent) and the women (88.9 percent), or a total of 905 students, included milk in their diets. Consumption was not seasonal, with 99.2 percent of the consumers indicating that they drank milk products throughout the year. However, only 71 percent of the males and 55.5 percent of the females consumed the same amount of milk each day.

Probably the greatest differences between the male and female consumers were in the type of milk they preferred and the average number of daily servings. Women students showed a decided preference for low-fat milk products (Table 2). By contrast, the men were fairly equally divided between those preferring low-fat milk (51.8 percent) and those preferring whole milk (46.3 percent). Seemingly the women were more concerned about calories than were the men. In their preference for low-fat milk, the women mirrored a 10-year trend of shifting away from whole fluid milk in the United States.

Only about 29 percent of the female consumers drank three or more glasses a day, as compared to 41 percent of the midwestern male students and 63 percent of the B.Y.U. males (Table 3). The relatively higher milk consumption by Mormons has been previously documented in a similar survey of adults beyond college age that we completed in Utah and southern Idaho. In that study, 46 percent of the Mormons and 32 percent of the non-Mormons consumed three or more glasses of milk daily.

By combining data from the college study and the earlier Utah-Idaho study, several generalizations can be made about age-dependent changes in milk consumption. When college men and the older men are compared, the consumption of three or more glasses a day declined by 21 percent among Mormons and 11 percent among non-Mormons. The percentage of Mormon women consuming at this level was 21 percent higher for the older group than for the younger one, while non-Mormon females consumed at approximately the same level. Thus changes in milk consumption habits by men would seem to account for a major portion of the age-dependent decreases in milk consumption.

While college students are often singled out as having poor nutritional habits, most of those in this study included significant amounts of milk in their daily diets.

Table 1. — Age and Sex Distribution of Students in Study

Sex	Age 18	19	20	21	>22
	percent				
Men	17.7	16.6	19.1	24.2	22.4
Women	22.0	27.0	22.0	17.5	11.5

Table 2. — Distribution of Type of Milk Preferred by 905 Student Consumers

Sex	Type of milk product: Skim	Low-fat	Whole	Powdered	Chocolate
	percent				
Men	42.5	7.7	46.3	1.6	1.9
Women	39.4	25.8	29.7	3.0	2.1
Av.	40.9	16.8	38.0	2.3	2.0

Table 3. — Distribution of Amount of Milk Drunk by 905 Student Consumers

	Av. no. glasses of milk/day: 1	2	3	4-6	>7
Midwestern Schools	percent				
Men	32.1	26.9	22.1	14.4	4.5
Women	28.7	37.5	30.3	1.6	1.9
Average	30.4	32.2	26.2	8.0	3.2
B.Y.U.					
Men	17.0	19.6	35.7	25.0	2.7
Women	37.4	34.1	22.0	6.5	..
Average	27.2	26.9	28.9	15.8	1.4

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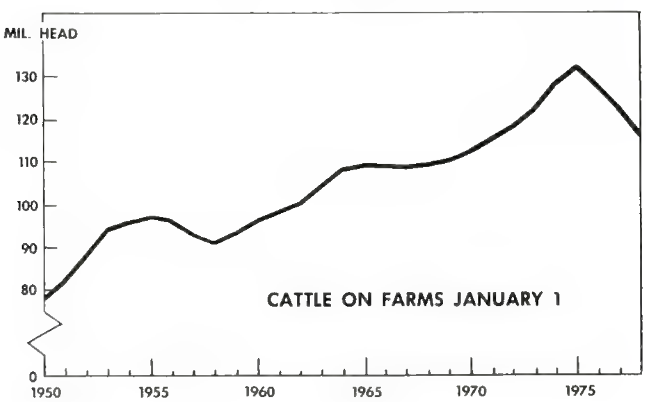
FARM BUSINESS TRENDS

After three years of low prices and financial losses, cattle producers can expect a sharp turnaround in 1978. Current trends indicate markedly improved profits in the cattle business for the next three years or longer. Beyond the early 1980's, the cattle outlook will likely deteriorate somewhat for producers as the cycle approaches another period similar to the late 1970's.

Records on the size of the U.S. cattle herd begin in the late 1800's. Since then, the size of the herd has varied up and down in a cyclical manner. During the early part of this century the cycle was fairly long — perhaps as much as 20 years from peak to peak. In the post-World War II period cattle numbers have peaked exactly every 10 years — in 1955, 1965, and 1975 (see figure).

Much of this cyclical movement seems to come from within the cattle industry. During the early phase of an upward trend in the cattle herd, producers are withholding animals from the slaughter markets. This has the effect of driving cattle prices above their long-term average. However, as the withheld animals begin to produce calves and these find their way to markets, prices move downward.



Lower prices mean reduced profits, which tend to cause the exit of some producers from the industry. As the departing cattlemen sell their animals, prices are depressed even further. A spiral of increasing slaughter and depressed prices continues until the herd is reduced sufficiently to call for higher prices. Biological lags between changing producer decisions and changes in the level of beef production largely determine the length of the cycle.

In 1978 the beef cycle will turn in the direction of higher prices and the accumulation of cattle on U.S. farms and ranches. Higher prices are already much in evidence. The January 1, 1979, U.S. cattle census will show fewer cattle than were on hand on January 1, 1978, but this will mark the low-water point for cattle numbers in the current cycle.

At their peak in 1979 or 1980, cattle prices will likely be considerably higher than they are now. With moderate increases in consumer demand balanced against somewhat larger supplies of competing pork and broiler meat, choice steer prices could easily move into the $70.00 to $90.00 per hundredweight area. A precise determination of the price level will depend critically on the strength of consumer demand and the reactions of hog and broiler producers. — *T. E. Elam, assistant professor of agricultural economics*

Winter, 1979

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

IN THIS ISSUE

Increasing numbers of consumers enjoy picking their own fruits and vegetables (page 12).

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ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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(Cover picture by H. A. Cate)

Winter, 1979 Volume 21, Number 1

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R. G. Cragle ....Director

Margery E. Suhre ....Editor, ILLINOIS RESEARCH

To receive ILLINOIS RESEARCH free of charge, write to the Agricultural Publications Office, 123 Mumford Hall, Urbana, Illinois 61801.

CORRECTION: In table 1, on page 4 of the fall issue, the headings "7-inch rows" and "20-inch rows" should be transposed.

A SEARCH FOR GREATER EFFECTIVENESS

THE MAJOR VALUE of the Agricultural Experiment Station lies in its community of scholars — a fairly numerous group of faculty members having a large degree of independence for conducting research that at some time will benefit citizens of the state and the country.

The selection of specific research projects depends on conditions both within and outside the University; priorities and choices must continually be adjusted in accordance with changing situations. Every time a new faculty member is appointed to the Station staff, for example, the research program is modified so that his or her particular expertise can be used most effectively. Often, too, priorities have to be shifted to conform with federal decisions.

Levels of funding through continuing federal and state monies also affect the number of research projects that can be undertaken and the scope of the investigations. At no time in the history of the Station have sufficient monies been available to initiate all the projects that have held promise of high returns.

Those of us on the administrative staff of the Experiment Station are very much aware of the constant effort being made to obtain research funds. No research professor can ignore the need for gifts and grants.

Although sheer volume of resources is necessary for a good effort, a second avenue toward more effective research lies in reexamination of the Station itself. We continually need to reassess our problems, opportunities, and organizational approach to solving our problems. For example, while independent research must continue, there is also great need for more team efforts calling upon multiple disciplines to formulate solutions to complex problems.

A continuing search for greater efficiency within the Station as well as for more resources may well yield a dividend of increased effectiveness that has not before been considered possible. — *R. G. Cragle*

The Greening of Higher Plants

An amazing picture of biosynthetic complexity emerges with the discovery of previously unknown chlorophylls and their precursors

CONSTANTIN A. REBEIZ, FAITH BELANGER, CHARLES E. COHEN, and SUSAN A. McCARTHY

EVERY SPRING, as annual and deciduous perennial plants form their green foliage, we witness the greening process at its most obvious. Not only is this phenomenon esthetically beautiful, but it is essential for life on this planet. More specifically, the greening process is a manifestation of the formation of chlorophyll (Fig. 1) by plant cells and its highly ordered integration into a lipoprotein matrix.

The lipoprotein membrane with its integrated chlorophyll is the fundamental structure (the photosynthetic membrane) that turns solar energy into chemical energy. Plant cells then convert the chemical energy into foodstuff. All life on planet earth depends on the foodstuff that green plants produce from carbon dioxide, solar energy, and water.

Scientists have been studying the formation of photosynthetic membranes for many years. Now recent discoveries in the Department of Horticulture have given us some startling new insights into this mysterious process. To describe our discoveries, we need first to review some of the previous research and beliefs in this area.

Constantin A. Rebeiz is professor of plant physiology; Faith Belanger, graduate assistant; Charles E. Cohen, research associate; and Susan A. McCarthy, graduate assistant, Department of Horticulture. The research reported here was supported in part by a grant from the National Science Foundation.

Renewed interest

Until recent years, studies of the greening process followed the conventional and familiar "analytical phase" of plant science research. Much was learned about the subject, but interest began to lag in the late 1960's.

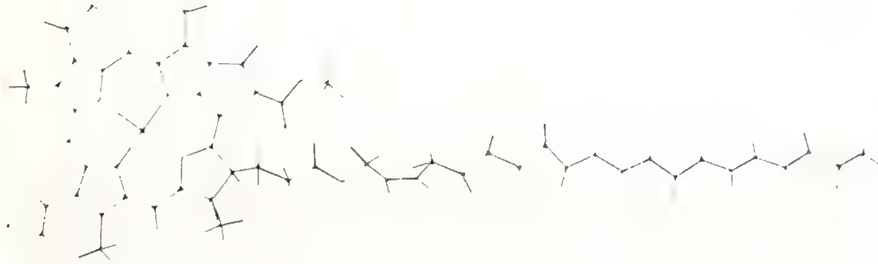
Then, about eight years ago, the greening process recaptured the imagination and attention of plant scientists. This renewed attention is now spearheading an interest in the "synthetic phase" of biological research. With the understanding that previous research has given us on plants' conversion of solar energy into chemical energy, many plant scientists have turned their attention to developing chlorophyll biosynthetically in the laboratory. Indeed, some scientists are attempting to duplicate photosynthetic membranes. A few hundred years ago, the same sort of trend resulted in the emergence of engineering as a "synthetic" science that fed on the advances achieved by the analytical physical and mathematical sciences.

In the process of trying to engineer efficient man-made photosynthetic membranes, it became evident that this effort depends on a deeper understanding of the way nature assembles the membranes during greening.

What has been believed

In the past three decades considerable progress has been achieved in understanding the greening process. Most of the reactions leading to the formation of chlorophyll from a simple five-carbon amino acid (δ-aminolevulinic acid) have been duplicated in the laboratory.

As a result of past research, chlorophyll biosynthesis has been visualized as a two-phase process that takes place in an organelle, the developing chloroplast, which is present in all greening cells of higher plants. The first phase consists of four reactions that convert eight molecules of δ-



Elaborate structure of the chlorophyll *a* molecule is indicated by this three-dimensional model. (Fig. 1)

aminolevulinic acid into a larger molecule — protoporphyrin IX. These reactions take place in the aqueous medium inside the developing chloroplast.

In the second phase, photoporphyrin IX becomes rapidly associated with the lipoprotein membranes of the chloroplast, and a membrane-bound enzyme inserts Mg^{++} into the protoporphyrin molecule, forming Mg-protoporphyrin IX. A series of about five membrane-bound and irreversible enzymatic reactions convert the Mg-protoporphyrin IX into a precursor of chlorophyll called protochlorophyll.

At this stage the protochlorophyll associates with lipoproteins to form protochlorophyll-protein complexes. These complexes react with light, and in the process the protochlorophyll is converted to chlorophyll *a*, the major type of chlorophyll found in higher plants.

Organizational complexity

It has also been believed that once a chlorophyll molecule is formed, it is then organized into the elaborate structures that make photosynthesis possible. This organization process involves, among other things, a simultaneous and highly complex biosynthesis of structural proteins and lipids inside and outside the developing chloroplast. Together with the chlorophyll, these proteins and lipids constitute the photosynthetic membrane.

Using highly sophisticated equipment, scientists in several laboratories have confirmed that the organization of chlorophyll is very complex. Chlorophyll *a* seems to consist of four to six different forms. These forms are believed to be made of one single kind of chlorophyll *a*. They result from various associations of chlorophyll molecules with one another or with lipoproteins (or both).

Each chlorophyll *a* form seems to play a specific role in the photosynthetic process. For example, one form appears to consist of two chlorophyll *a* molecules linked together by one or two water molecules. These chlorophyll-water pairs are believed to be the reaction centers where the initial conversion of solar energy into chemical energy takes place. The other chlorophyll *a* forms seem to be involved in collecting light energy and conveying this energy to the reaction centers.

Chlorophyll *b*, which is the other type of chlorophyll encountered in higher plants and which differs slightly in its chemical structure from chlorophyll *a*, is also organized into two different forms in the photosynthetic membranes. The two chlorophyll *b* forms appear to be involved exclusively in the collection of light energy.

Is complexity necessary?

The discovery of the complex organization of chlorophyll in the photosynthetic membranes has raised several questions that may have important practical implications. For example, is such organizational complexity absolutely necessary for efficient photosynthesis? If the answer is positive, as it seems to be, then we need to know more about the exact nature of this complexity and about its elaboration by the plant cell before it is possible to devise better man-made photosynthetic membranes.

Altogether, the unraveling of chlorophyll's organizational and functional complexity and determining the way in which plant cells assemble this complexity have emerged as active areas of modern photosynthesis research.

Emergence of a new complexity

Until very recently students of the greening process did not investigate the mechanism by which chlorophyll organizational complexity is built up in green plants. Instead, they were mainly concerned in understanding how one chlorophyll molecule can be put together from a simple amino acid such as δ-amolevulinic acid. When we recently directed our attention to the mysteries of the organizational complexity, an incredible picture emerged.

It appears from our work that the organizational complexity of chlorophyll begins early, during the conversion of protoporphyrin IX into protochlorophyll. This hypothesis is based on several observations:

1. At least five different protochlorophyll-protein forms apparently develop during greening.

2. Contrary to expectations, these photochlorophyll-protein forms do not seem to be made up of one single protochlorophyll species that associates in different ways with different lipoproteins. Instead, these forms seem to be made up of at least four chemically distinct protochlorophyll species. These have recently been identified as divinyl protochlorophyllide, protochlorophyllide, divinyl protochlorophyllide ester, and protochlorophyllide ester.

3. The multiplicity of protochlorophyll species making up the detectable protochlorophyll-protein forms seems to be accompanied by a biosynthetic complexity of the chlorophyll pathway. This complexity is manifested by a splitting of the chlorophyll biosynthetic chain into several branches.

4. Finally, our results suggest that, contrary to earlier beliefs, chlorophyll's organizational complexity (and probably functional complexity) may be due in part to the occurrence in green plants of more than one species of chlorophyll *a* and of chlorophyll *b*. The new species have been tentatively identified as divinyl chlorophyll *a* and divinyl chlorophyll *b*. Both of the new species are apparently formed from the protochlorophyll precursors mentioned above. Their immediate precursors appear to be divinyl chlorophyllide *a* and divinyl chlorophyllide *b* respectively.

Future prospects

The elucidation of this biosynthetic complexity may enhance our understanding of the molecular architecture of photosynthetic membranes and the basic mechanism by which plants convert solar energy into chemical energy. We hope that it will bring us closer to the day when it will be possible to develop man-made photosynthetic membranes.

Staphylococcal Food Poisoning:
New methods of detecting the causal organism

SCOTT E. MARTIN and GAIL P. ANDREWS

STAPHYLOCOCCAL food poisoning competes with *Salmonella* poisoning as the most common type of food poisoning in the United States. It is due to ingestion of enterotoxins produced by the bacterium *Staphylococcus aureus*.

Victims of staphylococcal food poisoning suffer from nausea, vomiting, abdominal cramps (which may be severe), diarrhea, sweating, headache, and prostration, but usually do not run a fever. Symptoms generally develop two to four hours after ingestion of contaminated food, but can appear any time between one and seven hours after eating. Fortunately, the symptoms usually last only a day or two and the mortality rate is very low. Treatment of otherwise healthy victims consists of bed rest and fluid balance.

Two factors account for the frequency of staphylococcal food poisoning. First, unlike most bacterial toxins, staphylococcal enterotoxins are very resistant to heat. Even boiling for 30 to 40 minutes will not completely inactivate them.

Second, *S. aureus* cells are widely distributed. They normally inhabit human skin; are found in the nose and throat; and are often isolated from infected cuts, wounds, burns, and boils. Thus, foods prepared by hand and served without further cooking (ham salad, for example) may be sources of staphylococcal food poisoning. The problem is intensified because these foods are often stored at temperatures at which *S. aureus* can grow and produce toxin (45°-110°F.).

A great variety of foods have been involved in outbreaks of staphylococcal food poisoning. Some of the most frequently implicated foods include cooked ham; meat products; poultry and dressings; sauces and gravies; cream-filled pastry; potato, ham, poultry, and fish salads; milk; cheese; and bread pudding.

Scott E. Martin is assistant professor of food science; Gail P. Andrews is a graduate research assistant.

Counting the bacteria

When a food is suspected of causing staphylococcal food poisoning, a sample is tested in the laboratory for the presence of *S. aureus*. Food processors also frequently test their ingredients for this organism.

One method for determining the number of bacteria in a food sample is to allow them to grow on a sterile agar medium. The food sample is first mixed in a sterile liquid to distribute the bacteria throughout the fluid. A small amount of this liquid is then spread over the surface of the agar medium in a Petri dish. The medium contains the nutrients that the bacteria need for growth. It is kept at the proper growth temperature (generally 95°F.) for one to two days. A colony will develop at every point on the agar surface where a bacterium from the sample liquid was deposited. Colonies are visible to the naked eye and can be counted to determine the number of bacteria in the original sample.

Selective media

A difficulty in detecting the presence of *S. aureus* is that the food sample may contain other bacteria that do not themselves cause illness but that do hide the presence of *S. aureus*. To overcome this problem, special selective media are used. They contain various chemicals (selective agents) that permit the growth of *S. aureus* while inhibiting the growth of other bacteria.

One commonly used selective agent is table salt (NaCl). *S. aureus* can grow well with as much as 10 percent salt in the growth medium while most other bacteria can not. Other selective agents used in staphylococcal media include tellurite, lithium chloride, and glycine.

Even the use of selective media does not guarantee the detection of *S. aureus* in a food sample. The organism can be injured by such food preparation processes as warming, freezing, drying, and freeze-drying. When the injured *S. aureus* cells are placed on staphylococcal selective media, they often can not grow and form colonies. Failure to detect these cells could permit the use of a contaminated ingredient in a food product. After a while, the injured cells could repair their damage, multiply, and produce enterotoxins.

According to work in our laboratory, one reason for the injured cells' failure to form colonies is that they produce hydrogen peroxide as they attempt to recover from their injuries. The combination of hydrogen peroxide and the selective agent inhibits colony formation.

Selective media have been developed for detecting the presence of injured *S. aureus* cells. The currently recommended medium is Baird-Parker agar. It contains pyruvate, which degrades the hydrogen peroxide produced by the recovering *S. aureus*. However, difficulties have been reported in the use of this agar, especially when milk products are sampled. It is also quite expensive.

New developments

We have developed an alternative selective medium, which is a modification of one developed by Vogel and Johnson and which we call

phosphatidyl choline — Vogel and Johnson agar (PCVJ). In addition to the original ingredients, the medium contains the enzyme catalase, which degrades hydrogen peroxide; phosphatidyl choline, a complex lipid that stimulates growth of injured *S. aureus;* beef extract, which adds nutritional value; and deoxyribonucleic acid (DNA) as a diagnostic aid. Compared with Baird-Parker agar, PCVJ permits equal or better enumeration of *S. aureus* at a reduced cost.

We also developed an alternative method for staphylococcal detection using a liquid medium. In doing so, we used the most-probable-number (MPN) technique, which is a statistical method of estimating bacterial populations. It is considered more efficient than agar plate methods when numbers of bacteria are low or levels of competing organisms are high.

The selective liquid medium that is currently recommended for staphylococci contains 10 percent table salt. We improved the medium by adding pyruvate to degrade hydrogen peroxide. With the use of this modification, we detected the presence of 2,300 *S. aureus* per gram of sample. We had not been able to detect any bacteria without the pyruvate.

We have shown that hydrogen peroxide is involved in the enumeration of other bacterial species. Investigations of this powerful metabolic by-product and its relationship to bacterial injury and recovery are continuing in our laboratory.

Looking Ahead—A Preview of Research On the Future of Illinois Agriculture

ROGER E. SCHNEIDER

ILLINOIS consistently ranks high among the states in agricultural production. Developments in Illinois agriculture thus have a significance beyond the state's borders in addition to their implications for the farmers, agribusiness, and total economy of the state. At the same time, as events in recent years have demonstrated, national and international developments affect the direction of Illinois agriculture.

The national and international forces influencing agriculture are constantly changing. Farmers and other agricultural decision-makers must respond to these uncertain and variable forces as well as to trends within the state, such as those in land markets and state tax policies.

Decisions made in this environment of change and uncertainty are often reactions to immediate needs and involve planning with a short time horizon. But the short-term decisions of today may have long-reaching results that are not compatible with unforeseen future needs. Potential trends in the more distant future are thus relevant even for short-range planning.

Whether the planning horizon is short-range or long-range, the quality of the decisions made is directly related to the amount and quality of information available about future directions. Research conducted by Experiment Station personnel continually augments our pool of such information. Even when research deals only with the present or past, the findings often have implications for the future.

A current research project in the Department of Agricultural Economics, however, seeks to deal explicitly with the future, as is indicated by its working title: "Farming in Illinois: Alternative Futures for the 1980's." This department-wide preview of the next decade was begun in early 1977 and is scheduled for completion in the fall of 1979.

Objectives and scope

The project has the following three objectives:

1. To describe the current characteristics of Illinois agriculture.
2. To develop alternative scenarios describing possible combinations of events most likely to affect the structure of Illinois agriculture in the 1980's.
3. To derive the possible implications of these alternative scenarios for Illinois agriculture.

In order to reach these goals, the broad subject of Illinois's agricultural economy has been broken down into a number of components. Each component is being studied by staff members with expertise in that particular area. These are the areas that are being explored:

1. Policies affecting Illinois agriculture.
2. International trade and Illinois agriculture.
3. Public opinion toward agricultural issues.
4. The legal environment for Illinois agriculture.
5. Potential competition for agricultural land.
6. Grain production and marketing.
7. Livestock production and marketing.
8. Dairy production and marketing.

Roger E. Schneider is research associate in agricultural economics.

9. Inputs for Illinois agriculture.
10. Issues in agricultural finance.
11. Food manufacturing and distribution.

Project participants are examining recent trends that have led to existing patterns in the state's agricultural economy. They are considering possible or probable future changes in these trends, the forces behind such changes, and the resulting effects on agriculture.

The types of problems being addressed and the analyses being conducted do not necessarily reflect novel approaches or new areas of interest to the researchers. Most of the participants are dealing with questions already of primary concern in their work. In fact, much of the final output from the project may be based on previous research results, as interpreted and applied to anticipating the future.

The distinguishing feature of the project lies in its organization and its scope, which goes beyond the boundaries usually set for research projects. Normally a researcher recognizes the interdependencies in the agricultural economy but, to attack a specific problem efficiently, he or she has to focus on a limited set of possible changes. Other variables are usually held constant. In this project, the work of several independent researchers is coordinated, allowing them to consider a variety of simultaneous changes. The questions they address individually are treated as parts of a related, consistent whole.

NIRAP system

The individual analyses must be consistent not only with one another, but also with reasoned projections of potential developments beyond the state's boundaries. To achieve this goal, the project participants are using information from the National Interregional Agricultural Projections (NIRAP) system. This is a system of computerized simulation models being developed by the Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture.

The NIRAP system links national farm production to the natural resource base, food consumption, the general economy, farm inputs, and world trade. The component models simulate the functioning of the national agricultural economy and the linkages between agriculture, the national economy, and the international economy.

Developers of the NIRAP system have used the concept of a scenario, or set of assumptions about key forces influencing agriculture. These forces are divided into those affecting demand and those affecting supply in agricultural markets.

Among the factors that influence demand are the rate of population change; economic growth as measured by changes in gross national product; annual growth rate of per capita disposable income; possible changes in tastes and preferences; and alternative levels for agricultural exports.

Major factors influencing supply are technological change, as measured by public expenditures on research and extension; the rate of inflation; and an index of general climate or weather conditions.

Alternative scenarios are developed by specifying different rates of change for the determinants of supply and demand. The NIRAP system projects the logical outcome of each scenario at the national level. The national results in turn lead to projections of expected production of agricultural commodities at the regional and state levels. Alternative responses of Illinois agriculture to a wide range of national and international developments can thus be compared.

Adjustments within the state

The state commodity projections from the NIRAP system could be interpreted as the logical outcomes of forces largely beyond the control of decision-makers in Illinois. Project participants will emphasize changes originating in the state as Illinois agriculture adapts to the levels and patterns of input use and commodity production projected by the NIRAP system.

Participants may deal with any matters relevant to future developments in their specialized areas as they consider anticipated problems, suggest possible solutions, and assess potential strengths in Illinois agriculture. The NIRAP system's projections are especially important as a foundation for those analyses concerned directly with agricultural commodity production, input needs, trade, and policy. Other analyses are less dependent on the NIRAP projections, but they are based on the same framework of interdependence that supports these projections.

Reports to be issued

At present participants are completing their analyses of major trends in the agricultural economy and are developing final projections for their reports. All reports will be issued simultaneously upon conclusion of the project.

In addition, a summary report will review the key findings of the individual reports and indicate what each report contains in the way of explanation and analysis. The summary will also provide an overall view of major trends and potential developments, with emphasis on the linkages between individual aspects of the state's agricultural economy.

The projections in this set of reports will not be definitive statements or predictions of what will happen in the future. Neither will there be any intent to prescribe what should happen. Changes that can not be controlled by decision-makers in Illinois may be anticipated and their potential effects measured. Other changes, however, will be due to reactions, adjustments, and choices by individuals and groups, both public and private, in the state.

Choices made by these groups and individuals will reflect their own informed projections of what is most likely to occur and what is most compatible with their wishes. The evaluation and decision process is always a subjective, tentative, trial-and-error procedure. It is hoped that the reports will broaden the base of knowledge for this process.

The Quality of Soybean Seed As Affected by Benomyl Treatment

RICHARD R. JOHNSON and GEORGE M. KEITH

In producing the high-quality seed necessary for successful soybean production, seed producers can encounter a variety of problems. Among these problems is that of disease.

Disease was particularly troublesome in 1977, because of wet weather in August and September. In an attempt to control seed-borne diseases, some seed producers sprayed their fields with the foliar fungicide benomyl [Methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate].

At that time benomyl had recently been labeled for use in controlling fungal leaf and stem diseases in soybeans. It had increased grain yields in fields with a high incidence of diseases such as pod and stem blight, Septoria brown spot, and anthracnose. However, its effects on seed quality were uncertain.

Seed produced in 1977 provided an excellent opportunity to determine the effectiveness of benomyl treatment. We accordingly compared samples from seed lots that had been brought to the Illinois Crop Improvement Association for germination testing prior to certification. All seed lots sampled came from eight central Illinois counties.

Twenty benomyl-treated and 20 untreated seed lots were selected at random in each of five varieties: Amsoy 71, Beeson, Corsoy, Williams, and Woodworth. Thus a total of 200 seed lots were sampled, of which half had been grown in fields treated with benomyl. It was assumed that the benomyl sprays had been applied according to label specifications.

Germination tests

Seeds were subjected to both warm and cold germination tests in the laboratory as well as to germination tests in the field.

For the warm germination tests, four replicates of 100 seeds were put on the surface of a moist Kimpac. Temperature was maintained at 25°C. (77°F.) for six days, after which seeds were rated for percent germination and percent strong seedlings. Strong seedlings generally have all plant parts intact and make relatively rapid growth. The percentage of seeds infested with pod and stem blight mycelium was also determined.

The warm germination test measures germination under ideal conditions. The cold germination test measures germination when conditions are stressful. It is a test of vigor.

For the cold test, two replicates of 100 seeds were planted 2.5 centimeters (1 inch) deep in a mixture of sand and unsterilized soil. The planted seeds were maintained in a cold chamber at 10°C. (50°F.) for seven days and then moved to a 25° C. (77°F.) chamber, where they were kept for four days. The percentage of emerged seedlings was then determined.

Growouts were conducted at Urbana and DeKalb, Illinois. At each location two replicates of 200 seeds each were planted in rows 6.1 meters (20 feet) long. Varieties were blocked within each replicate, and treated and untreated seed lots were randomized within a variety. Planting was done on May 10, 1978, at DeKalb and on May 27 at Urbana.

Differences due to variety

All measurements of seed quality indicated that varietal differences existed regardless of benomyl treatment (Table 1). In general, the two late-maturing varieties, Williams and Woodworth, germinated better in laboratory tests and had less pod and stem blight than the three earlier varieties. Benomyl treatment had no statistically significant effect on any of the laboratory ratings.

Germinated seedlings that were sampled eight days after planting. The two on the left have swollen hypocotyls. (Fig. 1)

The field tests were conducted on two quite different seedbeds. At DeKalb an intense 7.5-centimeter (3-inch) rainfall occurred the day after the seed had been planted 2.5 centimeters deep. Crusting conditions and cool weather prevented emergence until 16 days after planting. Benomyl treatment significantly improved average emergence of Amsoy 71, Beeson, and Corsoy (Table 1).

Since the Urbana seedbed was warm and drying out on top, seed was planted 3.8 centimeters (1½ inches) deep. Four days later, some

Richard R. Johnson is associate professor of agronomy; George M. Keith is manager of the Illinois Crop Improvement Association. Joe Lamb of the Crop Improvement Association and Francis McCoppin of the Agronomy Department gave technical assistance; the Illinois Soybean Program Operating Board provided partial funding for this project.

Table 1. — Comparisons of Warm and Cold Germination Tests and Field Tests for Five Varieties With and Without Benomyl Treatment

Variety	Warm test						Cold test		Field test			
	Germination		Strong seedlings		Pod and stem blight		Germination		DeKalb emergence		Urbana emergence	
	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
	percent											
Amsoy 71	84.0	81.8	76.8	73.9	9.1	10.7	55.6	49.8	40.8*	36.4	54.8	55.3
Beeson	76.0	76.9	66.2	66.2	14.0	12.2	59.0	42.7	46.1*	37.7	47.8	41.1
Corsoy	83.7	84.4	75.4	75.4	8.1	7.2	69.9	68.6	51.9*	45.5	74.4	72.9
Williams	89.5	89.2	84.0	83.5	2.1	3.4	73.0	81.0	48.7	49.3	48.8	52.9
Woodworth	85.7	85.0	78.3	77.6	5.8	6.0	73.4	76.3	44.1	43.1	37.3	36.1
Mean	83.8	83.5	76.1	75.3	7.8	7.9	66.2	63.7	46.3*	42.4	52.6	51.7

* Significantly different from untreated; the L.S.D. (0.05) to compare treated with untreated within a variety is 3.0 percent.

seedlings began to emerge. Final emergence was much better for Corsoy than for the other varieties. Benomyl treatment had little effect on the emergence of any variety (Table 1).

Inspection of a number of Urbana plots eight days after planting indicated that several seeds from varieties other than Corsoy had germinated and emerged to within 0.6 to 1.3 centimeters (¼ to ½ inch) of the soil surface. Some of these seeds were abnormal, but most were normal except for enlarged hypocotyls (Fig. 1). Many of the enlarged hypocotyls had developed splits, which became infected with pathogens within a week. Most infected seedlings failed to emerge completely.

The poor emergence of all varieties except Corsoy may be related to soil temperature. During the week after planting at Urbana, soil temperature at the 5-centimeter depth averaged 26°C. (79°F.). According to recent research at Iowa, hypocotyl elongation of some varieties is inhibited by germination at 25°C. This temperature is critical for differentiating varieties. A rating scale of 1 to 5 for elongation at 25°C. has been developed, with "5" indicating the poorest elongation. In tests at Iowa, Corsoy was rated "1" while the other four varieties were rated "4" or "5."

Table 2. — Correlation Coefficients of Several Laboratory Tests With Field Emergence

Variable	Variable				
	Strong seedlings	Pod and stem	Cold test	Urbana emergence	DeKalb emergence
Pct. warm germination	0.98**	−0.94**	0.46**	0.13	0.31**
Pct. strong seedlings	...	−0.91**	0.43**	0.10	0.29**
Pct. pod and stem blight	...	...	−0.46**	−0.08	−0.32**
Pct. cold germination	...	...	...	0.11	0.59**
Pct. emergence at Urbana	...	...	...	...	0.34**

** Significant at $P < 0.01$.

Table 3. — Range in Percent Germination of Emergence in 20 Benomyl-Treated Seed Lots and 20 Untreated Seed Lots in Each of Five Varieties

Variety	Pct. warm germination		Pct. cold germination		Pct. emergence at DeKalb	
	Treated	Untreated	Treated	Untreated	Treated	Untreated
Amsoy 71	73-89	72-89	17-86	20-80	17-61	20-52
Beeson	49-84	61-86	36-78	21-63	16-60	19-56
Corsoy	73-89	73-90	23-91	47-84	46-64	34-56
Williams	86-91	87-92	49-88	43-92	41-58	40-59
Woodworth	79-89	77-93	22-87	40-88	25-50	36-51

Other aspects

An interesting aspect of this study is the relationship of laboratory ratings to field emergence. None of the laboratory tests were correlated with emergence at Urbana because of the hypocotyl elongation problem. This is indicated by the low correlation coefficients in Table 2. (The closer a correlation coefficient approaches a plus or minus 1.0, the closer is the relationship between two variables.)

Emergence at DeKalb was correlated about equally with percent warm germination, strong seedlings, and pod and stem blight. These three tests were also highly correlated with each other. The test showing the highest correlation with percent emergence was the cold test.

Another striking result was the wide range in seed quality within a variety (Table 3). Although benomyl treatment improved average emergence of three varieties at DeKalb, the range of emergence within each variety still remained great.

Overall quality important

The large differences within treated seed lots showed that the treatment did not insure high quality. Seed lots with high germination tests performed best, indicating that overall seed quality is the major factor to be considered when buying soybean seed. As more research is conducted with foliar fungicides, it may be possible to further improve seed quality by improving time and rate of application.

Frequency of Financial Problems Related to Family Characteristics

JEANNE S. WILLIAMS, JEANNE L. HAFSTROM, and MARILYN M. DUNSING

Although a growing body of research concerns many aspects of family economic well-being, very few studies have been focused on the characteristics and life styles of families having frequent financial problems. To provide more information on this subject, a research project entitled "Factors Determining the Life Styles of Disadvantaged Families" has been inaugurated in the North Central region. The study described here represents Illinois's contribution to the regional project.

Obviously, some families' financial problems are due to inadequate incomes. They are the victims of what B. S. Rowntree, a British economist, called "primary" poverty. Other families with severe financial difficulties, however, are in a state of "secondary" poverty. They have adequate incomes to meet their requirements, but are not doing so.

To provide some insight into the two types of poverty, our research was planned to determine the relationships between family financial problems and several variables. These included family income and selected socioeconomic and social-psychological characteristics.

Sample characteristics

Data for our study were obtained from a comprehensive survey of family life styles conducted in Urbana-Champaign in 1970-71. Included in the survey were 287 homemakers from neighborhoods that had been identified by the Illinois Survey Research Laboratory as containing a high proportion of disadvantaged families. The women were all under 65 years of age and had at least one child under 18 living at home.

Most of the 287 families (81 percent) were white and the rest were black. Family size averaged 4.5 persons, with slightly less than three-fifths of the families having four persons or fewer, and slightly less than one-eighth numbering seven or more. Husbands were present in 73 percent of the families. Homemakers averaged 33 years of age; husbands, 36.

Mean family income before taxes was $7,961. Slightly less than half the families had incomes of $4,000 to $10,000; about one-third had higher incomes; and one-fifth had incomes below $4,000. (Median family income for the United States in 1970-71 averaged $10,080. For this same period, the low-income threshold for a nonfarm family of four was $3,855.)

About one-third of both the homemakers and the husbands had less than a high school education; about two-fifths had a high school education; and about one-fourth had more schooling. Most of the husbands (68 percent) had blue-collar jobs. Only 38 percent of the women worked outside the home. Most (59 percent) of the families were renters. Of the 234 families that had been formed at least five years, 58 percent had moved one or more times.

Financial problems groups

A multiple-item scale was developed to measure the frequency of nine financial problems: (1) not having enough food to last until payday; (2) getting behind on rent or house payments; (3) not being able to buy special things for children; (4) not having enough money for dentist, doctor, or medicine; (5) danger of having gas or electricity turned off; (6) inability to meet large bills; (7) not enough money to keep equipment and appliances in running order; (8) no money for new clothes or shoes; and (9) no savings to fall back on. An alpha of .86 was obtained for the scale, indicating a high degree of interrelationships among the variables in the scale.

The homemakers were asked how often they experienced these problems. Their total scores were used to divide the families into four groups according to the frequency with which they experienced the problems: never (18 percent of the families), seldom (30 percent), sometimes (26 percent), and often (26 percent).

Fifteen socioeconomic variables and 14 social-psychological variables were significantly related to the frequency of financial problems. Three budget levels — high, intermediate, and low — account for three of the variables. These levels were based on the Bureau of Labor Statistics consumption costs for a family of four and were modified for each family according to family size and composition. Forty-two percent of the families could not meet even the low budget, while only 9 percent could meet the high one.

The following discussions of the four groups include only the characteristics with actual frequencies significantly different from the expected frequencies.

Often have financial problems

Compared to other groups, families that often had financial problems were more likely to be large (seven or more persons), to be black, and to not have a husband living at home. Both husband and wife were more likely to have less than a high school

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education and the employed wife to have a blue-collar job. These families also tended to be in the two lowest income groups, have undependable incomes, and be unable to meet even the lowest budget level. They were more likely than the other families to be renters and to have moved one or more times within the preceding five years.

Women in this group tended to be dissatisfied with their housing and their levels of living and to feel that their incomes either were not at all adequate or could barely provide necessities. They were inclined to believe that they were worse off financially than they had been five years previously. They also expected a change in their standard of living during the next year.

Many of these women felt that their husbands did not understand their problems and feelings. In general, this group did not want their daughters to marry someone like their own husbands in occupation, personality, and ability as a provider. Rather, these women expected their daughters to marry someone better than their husbands.

An interesting point is the women's responses when asked about their aspirations — things they wanted for their family, family members, houses, and yards. The only one of these items that was significantly related to financial problems was the desire for things in the house. Women who had frequent financial problems wanted these things but tended not to discuss their wishes with other people.

Sometimes have problems

Families that sometimes experienced financial problems tended to be large (five or six persons). They were mostly white, and the husbands were younger, on the average, than those in the other groups. Most of the women had high school educations.

Women in this group generally felt that they could afford some but not all of the things they wanted. They were more likely than those with less frequent money problems to be dissatisfied with their houses.

These women were less satisfied with their marriages and with their husbands' understanding of their problems and feelings, although they were somewhat satisfied with the amount of time their husbands spent talking to them. They tended to expect that their daughters would marry someone the same as or not as good as their husbands.

Seldom have problems

Families that seldom had financial problems tended to be smaller (four or fewer persons) than the first two groups, and were mostly white. Husbands were usually present, with most of them being 40 or more years old. Both husbands and wives had high school educations.

The wives tended either not to work outside the home or to have white-collar jobs. The husbands, however, were likely to have blue-collar occupations. These families tended to have dependable, middle incomes ($8,000-$10,000), to own their own homes, and not to have moved during the past five years.

Women in this group tended to feel that they could buy some of the things they wanted. They considered themselves better off than they had been five years earlier and were generally somewhat satisfied or very satisfied with their houses and levels of living. They did not expect their standards of living to change in the year ahead.

In general, these women were content with their marriages. They were somewhat or very satisfied with their husbands' understanding of their problems or feelings and very satisfied with the time their husbands spent with them. They wanted their daughters to marry someone like their husbands in occupation, personality, and ability as a provider; they did not expect them to marry someone who was a better provider.

Never have problems

As expected, families that never experienced financial problems had the highest incomes and were most likely to be able to meet the intermediate and higher budgets. On the average, the husbands were older than those that often or sometimes experienced financial problems, and were likely to have white-collar jobs. Both husbands and wives tended to have more than a high school education.

Implications

Significant relationships were found between the frequency of financial problems and selected socioeconomic and social-psychological variables. Among these variables were some of the homemaker's perceptions, satisfactions, and expectations.

The findings of this and similar studies are valuable for use in educational programs. For people with inadequate incomes, educational programs need to be aimed at improving job skills, increasing employability, and increasing awareness of alternatives that will help solve economic problems.

It is in overcoming the problem of "secondary" poverty that studies like the present one are most helpful. Results can suggest possibilities for educational programs that will help people manage their resources more wisely. For example, programs might be developed on the costs of moving frequently, of renting versus home ownership, and of different types of housing.

Additional research is warranted to find out if the relationships found in this study are true in other samples and other communities. It is suggested that future studies include more social-psychological variables so that a greater insight can be obtained into their relationship with the family's economic well-being. There is also need for analyses to determine whether there is a cause-and-effect relationship between satisfactions and expectations on the one hand and financial difficulties on the other hand.

Any way in which we can increase our understanding of the socioeconomic and social-psychological characteristics of families having financial problems should provide the insight needed to help improve family well-being.

Direct Marketing Of Fruits and Vegetables – A Fresh Approach

Farmers' community markets are popular with consumers. (Fig. 1)

J. W. COURTER, ROBERTA ARCHER, C. M. SABOTA, and R. E. WESTGREN

CONSUMERS like to buy fruits and vegetables directly from farmers because of the freshness, vine-ripe quality, and price advantage. Some consumers may find community farmers' markets most convenient; others may prefer roadside stands; and still others may want to harvest their own produce at a "pick-your-own" farm (also called PYO or U-pick).

Sales from the producer directly to the consumer now account for an estimated 25 to 30 percent of all horticultural food crops grown in Illinois for the fresh market. Direct marketing is an important method of sales for many major producers and is also a means of supplementing income for small operators and part-time farmers. Without direct marketing, the acreage of small fruits in Illinois would probably be greatly reduced.

In 1977 a two-year study to "improve the efficiency of farmer-to-consumer marketing in Illinois" was begun by the Illinois Cooperative Extension Service and the Illinois Department of Agriculture in cooperation. The study has a dual approach: (1) to bring more farmers to consumers through community farmers' markets and (2) to bring more consumers to "pick-your-own" farms.

The first phase of the study has been an assessment of the current situation. This preliminary step will enable us to establish specific projects and measure future development.

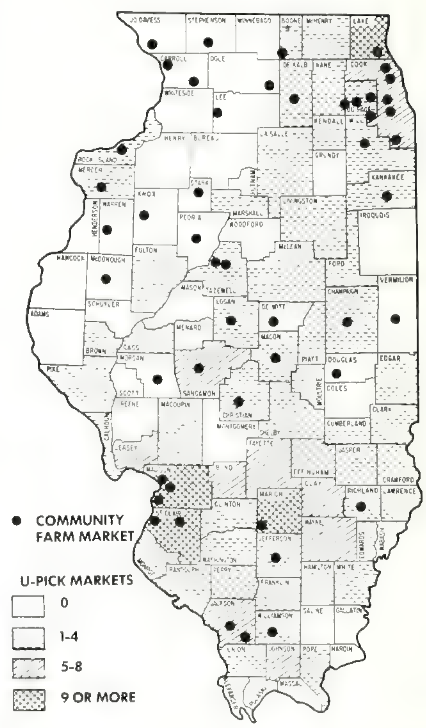
Location and number of markets

Direct markets are located throughout Illinois, according to surveys made in 1978 with the assistance of county Extension advisers (Fig. 2). Although heavily populated areas tend to have the greatest concentrations of community farmers' markets and PYO farms, both types of market are successful in rural counties when the number and size of the markets are not too great for the population.

In 1978, 48 communities had farmers' markets — more than twice as many as in 1977 and six times as many as in 1973. Downtown Business Associations or Chambers of Commerce sponsored 69 percent of the markets. Of the producers selling at community markets, 85 percent farmed within 27 miles of the market, 87 percent sold only their own produce, and most sold at two different markets. The majority derived less than 10 percent of their total income from these sales.

The number of PYO producers has risen substantially in recent years. For example, about 40 percent more farmers grew strawberries for pick-your-own in 1978 than in 1968. Many producers who formerly sold only in wholesale markets have adjusted their acreages to meet local demands.

Because of topography, availability of irrigation water, and location of soils best suited for horticultural crops, a number of commercial enterprises are located in areas that



Distribution of U-pick and community farmers' markets in Illinois. (Fig. 2)

J. W. Courter is professor of horticulture; Roberta Archer, marketing specialist, Illinois Department of Agriculture; C. M. Sabota, Extension assistant in horticulture; and R. E. Westgren, assistant professor of food marketing in Agricultural Economics. Funds were authorized under the Farmer-to-Consumer Direct Marketing Act of 1976.

are not highly populated. Thus, some producers feel they cannot take advantage of direct marketing. Others, however, have not fully realized their potential. The distribution of PYO farms suggests that opportunities for direct marketing exist near many Illinois cities and towns.

Crops in direct markets

A wide variety of vegetables and fruits is sold directly to consumers by Illinois farmers. The leading crops, listed in Table 1, returned an estimated 8 to 10 million dollars to direct market producers in 1978. Strawberries, apples, tomatoes, sweet corn, and peaches each brought in 1 million dollars or more.

Illinois strawberries, blueberries, blackberries, and raspberries are marketed almost entirely through direct-to-consumer sales, mostly U-pick. Virtually all the apples produced in the northern half of the state are also sold in direct markets, with U-pick accounting for about half of the sales. Most new plantings of apples in the state are planned for direct marketing.

Consumer benefits

We estimate that 750,000 to 1 million consumers patronize direct markets in Illinois each year. Some customers may return to a conveniently located market once a week or oftener. By buying directly from the farmer, consumers typically save 19 cents on every dollar spent.

When customers at 10 community-farm markets were surveyed in 1978, most of them gave fresh, vine-ripe quality as the top reason for patronizing these markets. The importance of quality was confirmed by U-pick customers at the Dixon Springs Agricultural Center. These customers also gave local availability of produce and price savings as important reasons for patronizing a pick-your-own market. They attached least importance to the recreational aspects and, surprisingly, the cost of gasoline. The rural background of most of the patrons may account for the relative unimportance of these factors in this particular study.

Table 1. — Horticultural Crops Sold in Direct Markets in Illinois in Order of Economic Importance

Crop	Annual production for fresh sales	Estimated amount direct marketed[a]
	1,000 lb.	*pct.*
Strawberries	7,000-10,000	95
Apples	90,000-100,000	15-20
Tomatoes[b]	18,000	20-30
Sweet corn[b]	5,000,000 doz.	20-25
Peaches	20,000	25-35
Melons	30,000	40-50
Pumpkins[b]	15,000	40-50
Beans[b]	5,000	20-25
Squash	4,000	25-35
Peppers	6,000	5-10
Blueberries	250-300	90-95
Raspberries, blackberries	100-150	90-95
Cucumbers, pickles	8,000	5-10
Greens	3,000	25-30
Plums, pears, cherries	100-150	70-75
Cabbage	17,000	1-2
Grapes	400-600	10-20

[a] Percentage of annual fresh market production that is sold through roadside or on-farm markets, community-farm markets, and pick-your-own.
[b] Significant acreages of these crops are also grown for processing.

The advantages of patronizing pick-your-own farms or farmers' markets lose their appeal for most people when they live farther than about 20 miles from the farm or market. This is evidenced by the replies that customers at Dixon Springs gave to the question: "Would you be willing to drive twice as far as you do now to pick your own produce?" Of those who lived within 10 miles, 85 percent said yes. Of those living 11 to 20 miles away, only 38 percent were willing to drive twice as far. This percentage dropped to 13 for customers who lived more than 20 miles away.

U-pick strawberry farms

Questionnaires asking about distance traveled and picking habits were distributed to more than 6,000 customers at 20 U-pick strawberry farms in 1978. About 30 percent of the questionnaires were returned. According to the replies, the average customer traveled 20 miles to the farm, picked 23.3 pounds of berries, and paid $8.59.

Trade areas were mapped around the farms to show the location of the customers replying to the questionnaire. Demographic information (income, age, family size) will be used to profile U-pick customers. A similar study of non-customers will be made in 1979 and 1980 under a contract with the Economics, Statistics, and Cooperatives Services, U.S. Department of Agriculture.

Information from these studies will be analyzed to develop planning aids for U-pick operators in making the most of their existing markets, enlarging their trade areas, and increasing production. Increased knowledge of U-pick customer characteristics and market potential will also aid in the establishment of new direct marketing operations.

Other activities

As part of our project, we have helped communities to evaluate the feasibility of local markets, organize downtown markets, and get in touch with producers. Practically all nonfood retail merchants have favored the markets.

Consumer buying habits, obtained at 10 community markets in 1978, are being summarized. The information will help managers and producers to plan production and markets.

Several directories — *Community-Farm Markets, You Pick Strawberries,* and *U-Pick Fruits and Vegetables* — were published by the Illinois Department of Agriculture in 1978. News releases and radio and television programs featured information about the Illinois direct market program and the directories. Similar activities are planned for 1979.

Proceedings published by the Department of Horticulture present guidelines for direct marketing and cultural recommendations. The *Roadside Market Conference Proceedings* and the *Community-Farm Market Conference Proceedings* were made possible by the direct market program. Other proceedings available are from the *Illinois Strawberry School, Illinois Small Fruit School,* and *Illinois Vegetable Growers' Schools.*

Some Responses of Rumen Bacteria to Starvation

JANE ZEIGLER LEEDLE and ROBERT B. HESPELL

THE RUMINANT animal's unique ability to convert plant materials into products useful to the animal has been well established. In accomplishing this task, the ruminant must depend upon microorganisms in its rumen and gastrointestinal tract to break down cellulose- and starch-laden plant materials into products that the animal can digest or absorb. These products, along with the microbial cells themselves, make up most of the nutrients available to the animal.

The microbial population of the rumen is a mixture of bacteria and protozoa, which are intensely active in the alteration of feed materials. Other characteristics of the rumen's anaerobic ecosystem include a relatively constant temperature and pH, and an atmosphere of carbon dioxide and methane. The ruminant animal thus provides an excellent ecosystem in which to study the metabolism of anaerobic bacteria.

Response to starvation important

In previous studies of the metabolism of bacteria, the organisms have usually received abundant nutrients although growth conditions have been varied. However, in most natural ecosystems, a bacterium may get inadequate or no nutrients during much of its life. Few studies of anaerobic bacteria and none of rumen anaerobes have dealt with the effects of starvation on these organisms. Yet the response of rumen bacteria to starvation is of special concern because of their importance to the host animal.

With a regimen of feeding once or twice a day, some metabolic groups of bacteria within the rumen may well undergo starvation. After feeding, the number of bacteria capable of metabolizing only a specific component in the feed will increase, following the pattern of fermentation of that substrate. But as fermentation continues, those bacteria start to die for lack of food. For example, after most of the dietary starch is fermented, many of the starch-degrading bacteria may starve. Enough must survive, however, to efficiently degrade the starch component of the next feeding.

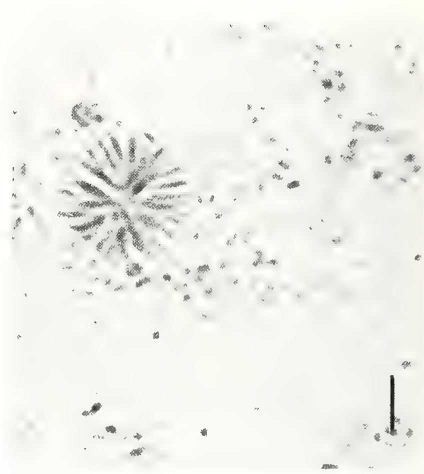
At present, virtually nothing is known about how well rumen bacteria survive changes in nutrient concentrations. Some bacteria can produce a starvation-resistant form such as a cyst or spore, but none of the predominant rumen microorganisms have this ability.

Other bacteria, such as soil microbes, can remain alive by shifting their rates of metabolism from a "normal" to a low basal or resting rate. This mechanism may occur among rumen bacteria.

Another survival mechanism in rumen bacteria may simply be to multiply abundantly while nutrients are available. Even after prolonged starvation, enough living bacteria would remain to replenish the population at the next feeding.

Bacteria starved in laboratory

In our laboratory we are studying a mixed population of rumen bacteria totally starved of nutrients. We collect rumen contents from a fistulated cow, blend the sample under carbon dioxide, and strain it through cheesecloth. The bacteria are separated from small feed particles and protozoa by centrifugation, and finally are washed free of any residual fermentation products and nutrients. These washed bacteria are then



Mixed rumen bacteria. Size is indicated by the bar, which equals 10 microns or 10 millionths of a meter. (Fig. 1)

starved in a non-nutrient solution (S Buffer), which is similar in mineral composition and pH to the saliva that enters the rumen in quantities of 40 to 200 liters a day.

To monitor changes in composition of the mixed bacterial population during starvation, we have developed several recovery media. A different carbohydrate is incorporated into each medium, and the metabolic groups are differentiated according to the ability of the starved bacteria to form colonies (grow) on the various media. For example, cellulose-degrading bacteria grow on the cellulose-containing recovery medium.

According to our early data, the basal medium without added carbohydrates permitted about the same number of rumen bacteria to grow as did a complete medium with all the carbohydrates, except that the bacterial colonies did not grow beyond pin-point size. This indicated to us that the basal medium contained all nutrients necessary to initiate growth, but that the lack of carbohydrate energy sources prevented continued growth (large colonies).

Survival assessed

We use several methods to assess the survival of mixed rumen bacteria during starvation. For one thing, we determine viability, or the total number of bacteria producing colonies on the recovery media. We also measure several cellular constituents to

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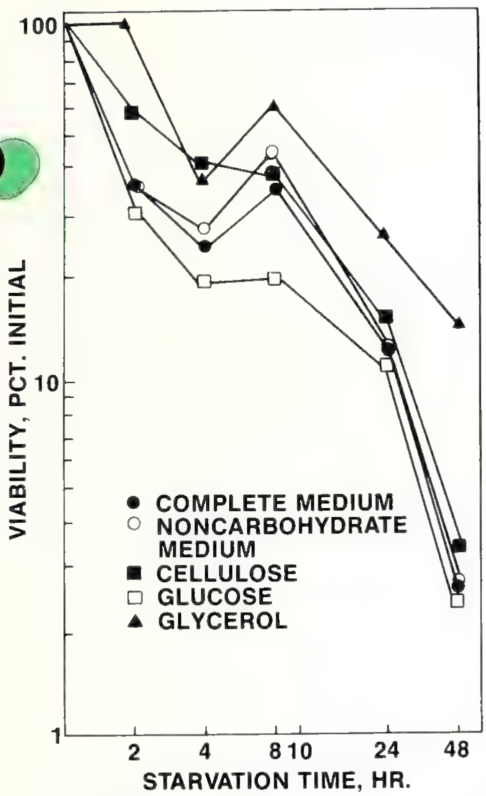
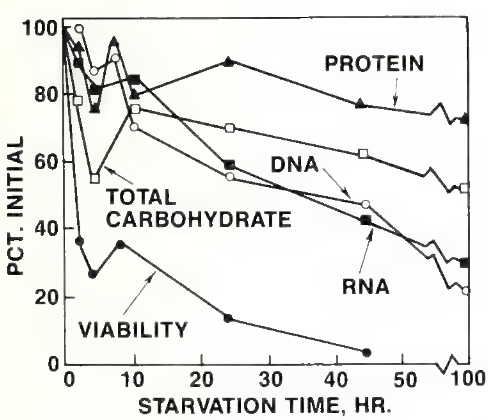
Jane Zeigler Leedle is a graduate research assistant and Robert B. Hespell, assistant professor of microbiology, both in the Department of Dairy Science.



Survival pattern of metabolic groups of rumen bacteria, as indicated by their growth on five selected media. (Fig. 2)



Trends in viability and in four constituents of rumen bacteria under total nutrient starvation. (Fig. 3)

secure data on internal changes in the bacterial cells. These constituents are DNA, RNA, protein, and total carbohydrate and glucose concentrations. Bacteria are collected for testing at various times during starvation. Fermentation acids released by the bacteria into the suspending solution are analyzed by gas chromatography.

According to preliminary results, both the total bacterial population (on the complete recovery medium) and the individual metabolic groups follow a survival pattern consisting of three phases: At first, viability declines rapidly as soon as nutrients are withdrawn. After about two hours, the population appears to stabilize for a while. Then, about 24 hours after starvation begins, there is another rapid loss of viability. Of the various metabolic groups, the glycerol-fermenting bacteria appear to withstand starvation best (Fig. 2).

The initial rapid loss of viability might simply be that the bacteria are dying by lysis, that is, by falling apart. However, a decline in cellular DNA is an indicator of lysis, and such a decrease does not occur in the first two hours (Fig. 3). After four hours, DNA and viability increase slightly. This increase probably reflects "cryptic growth" or growth of living bacteria on cell products released from dead bacteria.

RNA, total carbohydrate, and protein also decline during starvation but not as dramatically as viability. During the first 10 hours these components decrease, indicating their degradation, then increase slightly. This is followed by a continual decline during the rest of the 100-hour starvation period.

Of the fermentation acids that result from the degradation of all cellular components and that are subsequently released into the S Buffer solution during starvation, acetate is the major volatile fatty acid. Propionate and butyrate are also produced, although the concentration of each is one-tenth that of acetate. The relative concentrations of these acids are much like those normally found in the rumen.

Tentative conclusions

Even at this early stage of our research we can draw some tentative conclusions. The first and foremost is that rumen bacteria under total nutrient starvation have an extremely poor survival capacity. Within the first two hours, 60 percent or more of the initial population fails to form colonies on either the complete or the noncarbohydrate basal medium. Also it appears that the large polymer utilizers such as the cellulolytics and glycerol fermenters have a better survival capacity than soluble carbohydrate utilizers.

Cryptic growth does occur, as evidenced by the slight increase in various cell constituents after two hours of starvation. This does not help the overall situation, however, because as these nutrients also become exhausted the viability of the population again rapidly declines. All cellular components seem to be degraded by the rumen bacteria during starvation — apparently in an effort to stay alive by degrading "non-essential" cell constituents.

Although acetate is the major acid produced by degradation of cell components during starvation, the other acids may be just as important, depending on the fermentative pathway used by a particular metabolic group or species of bacteria. The relative abundance of an acid may directly relate to the survival of a particular group under starvation.

Future research

In the future we plan to determine the succession of the various metabolic groups in the animal after once-a-day feeding. We also hope to assess the influence of change in diet on the metabolic makeup of the rumen microbial population. Especially interesting would be the bacterial changes that occur during the transition from one type of diet to another.

Data generated from this research should be useful to both the microbiologist and the dairy scientist. With knowledge of the progression of metabolic groups within the rumen and of the conditions that help them to survive starvation, new diets might be formulated or changes made in the frequency of feeding. This would undoubtedly be of aid in maximizing the microbial growth yields within the rumen and improving feed efficiencies.

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FARM BUSINESS TRENDS

BETWEEN 1967 and 1977, Illinois gross farm income increased 225 percent, going from $2,918 million to $6,565 million. Increases in gross income averaged about 2.5 percent annually from 1967 through 1971, then reached 21 percent in 1972, 39 percent in 1973, and 15 percent in 1974. These increases were followed by a drop of 7 percent in 1975, an increase of about 18 percent in 1976, and a slight decline in 1977.

Gross farm income includes receipts from crops and livestock, government payments, and other farm income, such as machine hire, custom work, and similar activities.

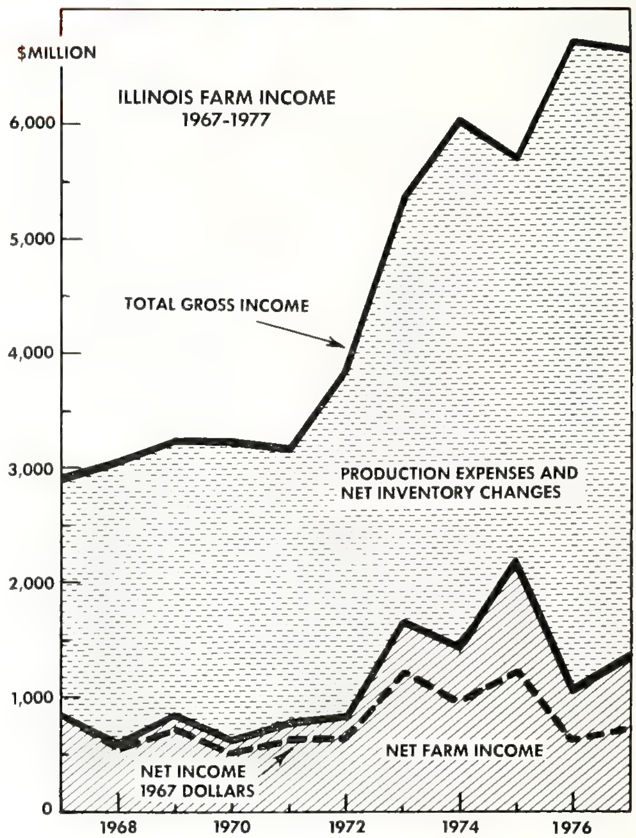
Government payments averaged 3 to 6 percent of gross farm income annually from 1967 through 1973 but less than 0.5 percent from 1974 through 1977. Illinois farmers received $32 million in government payments in 1977. New programs enacted in 1977 and 1978 may increase payments to nearly $50 million.

Before the early 1960's, cattle sales were the major source of gross farm income in Illinois. However, by 1967 they had dropped to 16 percent of the total and in 1977 were only 9 percent. Hog sales were 19 percent of gross farm income in 1967, but decreased to 9 percent by 1977.

Corn sales made up 23 percent of gross income in 1967, reached 34 percent by 1976, and were 28 percent in 1977. Soybean sales ranked fourth in 1967, accounting for 15 percent of gross income, but by 1970 reached 19 percent and a second-place ranking behind corn. In 1977, soybean sales were 26 percent of gross income, again exceeded only by corn sales. Final 1978 figures may show soybeans surpassing corn in percentage of gross income.

In 1967 livestock and crop receipts were about equal in their contributions to gross farm income, but in 1977 crops made up about 60 percent and livestock about 30 percent of the total.

Rises in gross income have been accompanied by rises in production expenses. These expenses increased by an average of 4 percent a year from 1967 to 1971, 17 percent in 1972, 28 percent in 1973, and about 5 percent in 1976 and in 1977. The fixed nature of many expenses prevents total expenses from falling even though gross income occasionally declines.



Illinois farm incomes may be increased slightly in 1978. Livestock receipts will be up because of higher livestock prices resulting from a downturn in the cattle cycle. Crop receipts were better supported in 1978 than in 1977 as a result of some support from CCC loan programs.

On a constant dollar basis, net farm incomes in 1976, 1977, and 1978 about equal 1967 to 1972 levels. — *R. B. Schwart, Extension economist, farm management*

Spring, 1979

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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These little pigs stayed home — and kept themselves warm (page 8).

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE Volume 21, Number 2

ILLINOIS RESEARCH

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(Cover picture by Paul Hixson)

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RESPONDING TO THE NEEDS OF SOCIETY

TRADITIONALLY the Agricultural Experiment Station has hired well qualified professionals and given them a great deal of freedom to shape their own research programs. This policy has capitalized on individual initiative and creativity. In contrast, the research programs of some government agencies and most private industries are more team oriented with specific goals to achieve.

Both approaches to research have a place within our society. While the University must continue to guard well the individual's freedom of inquiry, we must also recognize the great advantages of the nation's mission-oriented research.

Society is now faced with an array of very difficult problems, many of which present research opportunities for the Experiment Station. Of vital concern is how best to use our capabilities to solve these problems.

In the years ahead the Station, along with other research units at the University of Illinois, will hold a crucial position in assessing energy development from biomass, intensifying soil conservation efforts, studying the use of water resources, and establishing policy to preserve land for agricultural production. Because of their complexity, these problems call for a multidisciplinary team approach. At the same time, however, the thrust of fundamental research must continue in pathology, genetics, nutrition, physiology, biochemistry, and related areas.

Clearly we should chart a course that includes both time-proven individual research and mission-oriented teams. We also need to strengthen our response to society. In the process we will open up new opportunities for the agricultural community and give new dimensions to the service provided by the Agricultural Experiment Station. — *R. G. Cragle*

Propagation of Roses With Tissue Culture

ROBERT M. SKIRVIN and MEL C. CHU

PRODUCING rose bushes is becoming too costly for many commercial propagators, mainly because of the large amount of skilled labor needed for budding. This propagation method, which is the one normally used, consists of grafting a bud from a desired variety onto a hardy rootstock.

While labor costs are rising, the price that customers are willing to pay has not increased appreciably. A method of propagating roses that is faster and less costly than budding is therefore needed.

The answer to the problem may lie in tissue culture. In this method, cells from very small pieces of plants are proliferated on an artificial medium under sterile conditions. Sources of plant tissue include embryos, seeds, stems, leaves, shoot tips, root tips, callus (wound tissue), single cells, and pollen grains. A tissue may be induced to remain unorganized indefinitely (as a callus) or to develop roots, shoots, and intact plants.

The use of tissue culture for rapid propagation has virtually revolutionized the production of such plants as chrysanthemums, orchids, ferns, and carnations. In the future, tissue culture will probably be of greatest value in propagating perennial plants that are difficult or slow to propagate asexually — for example, apple trees, peach trees, and, perhaps, roses.

Shoot tips studied

Recently we began a study to develop methods for tissue culture propagation of greenhouse roses. Initial experiments were conducted with shoot tips from the Forever Yours variety.

Robert M. Skirvin is assistant professor of horticulture and Mel C. Chu is associate horticulturist.

The tips were surface-disinfected with a solution containing 10 percent Clorox and 0.1 percent Triton X-100 for 10 minutes. This was followed by three 5-minute rinses in sterile distilled water. Some of the tips were then transferred onto a shoot-proliferating medium that had previously proved useful in proliferating shoots from peaches, which belong to the rose family. Other tips were explanted onto rooting media.

The shoot-proliferating medium consisted of the Murashige and Skoog (MS) medium supplemented with 2 milligrams of 6-Benzylaminopurine per liter, 0.1 milligram of α-naphthaleneacetic acid (α-NAA), and 50 milligrams of ascorbic acid, plus Staba vitamins. For rooting, the MS medium was supplemented with 50 milligrams of ascorbic acid per liter, Staba vitamins, and various levels of α-NAA.

All cultures were grown in continuous light at about 23°C (73°F).

Results are encouraging

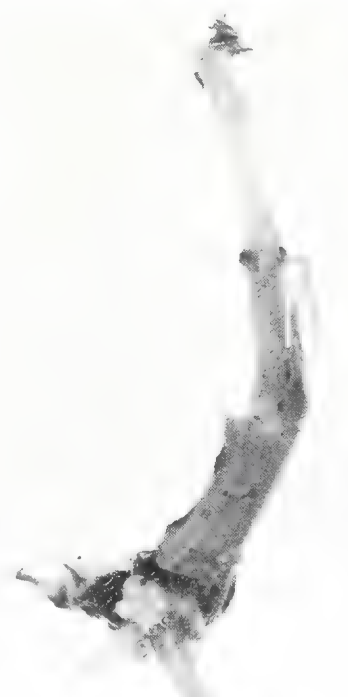
Within five weeks about 25 percent of the shoot tips on the shoot proliferation medium developed multiple shoots (Fig. 1). These tips were separated and placed on fresh medium, where they have continued to proliferate through three or more generations.

During the same period 10 to 20 percent of the shoots on rooting media supplemented with 1 to 3 milligrams of α-NAA per liter developed roots as shown in Figure 2. (Much better results — up to 80 percent rooting on some media — have been attained in later experiments.)

We are now devising methods to insure optimum survival of the rooted shoots after they are planted in soil.

Successful tissue culture propagation of roses not only would eliminate the cost of budding, but would offer several other advantages as well: Virus-free forms of popular varieties could be developed. Varieties could be stored in culture tubes until needed, reducing the cost of maintaining large numbers of varieties in soil. And rose plants could be produced the year round regardless of weather conditions.

Multiple shoots formed on shoot-proliferation medium. (Fig. 1)



Root formation on MS medium with 2 milligrams per liter of α-NAA (Fig. 2)

Capturing The Sun's Energy In Woody Biomass

G. L. ROLFE and T. A. WHITE

With the energy crisis of recent years, the need to harness solar power grows ever more urgent. The scientist's challenge is to efficiently capture the sun's energy, store it, and ultimately convert it into usable forms.

Collectors of solar energy

A number of devices have been produced to collect solar energy. Heating mechanisms such as flat plate and tube collectors and electrical photovoltaic cells directly utilize the sun's rays. Unfortunately, storage and economic problems have so far kept these devices from reaching the public.

However, another collector of solar energy has good potential for general use. This collector is ubiquitous, readily available, and capable of storing large quantities of solar energy for indefinite periods. It can also regenerate itself. In past eons it collected 94 percent of the energy being used today. This solar energy storehouse consists of living and dead vegetation.

Plants capture solar energy through photosynthesis. During this process various components (such as carbohydrates, lignin, extractives, and minerals) are formed from elements and water taken from the soil and from carbon dioxide in the air. In the presence of chlorophyll (the green coloring in the plants), the carbon dioxide is combined with oxygen and hydrogen from water to form dextrose, a simple sugar. The energy needed for the complicated reactions leading to the formation of dextrose, and ultimately of cellulose, is supplied by sunlight.

When you burn dry wood in the fireplace, you recover solar energy stored in the wood. If you burn 100 pounds of dry wood, you release about the same amount of heat as when 1,000 cubic feet of natural gas, 7 gallons of No. 2 fuel oil, or 68 pounds of coal are burned.

Biomass as energy source

The food and tissue that plants generate are called *biomass*. Technically speaking, biomass is any biologically produced matter and includes all of our flora and fauna. Agricultural and silvicultural crops are biomass as well as livestock and the wastes they generate. However, the energy community has come to consider biomass as biological materials that may be used as feedstock for conversion into such energy forms as steam, alcohol, or methane.

Biomass offers many advantages as an energy source. In addition to those already mentioned, biomass generally is environmentally acceptable because most forms are pollution-free. Biomass production does not significantly alter the earth's crust as does strip mining. It is not a source of thermal pollution like fission nuclear power. The conversion of biomass into heat does not upset the biosphere's carbon dioxide balance as fossil fuels do. Moreover, currently unproductive, marginal land may be used to continually produce biomass with present agricultural and silvicultural methods.

Biomass research is increasing rapidly. Research directions include the utilization of herbaceous and woody vegetation (both living matter and dead residues), sewage, and manure as feedstocks. Harvesting and transportation techniques are being developed as well as various conversion processes. Ways to increase economic feasibility are also being studied.

Advantages of woody biomass

If one is growing plants specifically for biomass production, woody species are often preferable to herbaceous species. Many herbaceous species require relatively fertile, productive land in isolated regions with long growing seasons. Woody biomass, on the other hand, can be grown under a host of site conditions in a variety of climates. Virtually any area of the country can produce biomass from native tree species.

Most broad-leaved woody species can sprout from the stumps of harvested trees in a process known as coppicing. Several harvests can thus be made from a single planting, reducing labor requirements, costs of planting, capital investment, and cost per unit of energy.

Current research

The Department of Forestry has recently initiated research on solar conversion through woody biomass production. The purpose is to assess the feasibility of growing woody biomass over short rotations on marginal lands.

Plantings will be made near the Urbana-Champaign campus and at the Dixon Springs Agricultural Center in southern Illinois. Cottonwood, sycamore, alder, and autumn olive will be grown at several spacings over two-year rotations on both bottomland and upland marginal sites.

The energy used to plant, maintain, and harvest the study plots will be closely monitored and balanced against the energy content of the biomass produced. In addition, nutrient requirements for biomass production and nutrient contents of the plant material will be determined. With this information, we can judge the effect of intensive, short-rotation biomass production on soil nutrients, especially nitrogen and phosphorus.

Much of the technology for establishing and managing energy farms already exists. But information is lacking on the use of herbicides for

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weed control in broad-leaved tree stands. Closely spaced plantations of highly productive trees do not allow for mechanical cultivation, so herbicides are being continuously screened for use with these species. Pilot studies during the 1978 growing season produced encouraging results. A number of herbicides provided good control of grass and broad-leaved weeds without appreciable harm to the energy crop. However, as with conventional agricultural crops, a particular herbicide may work well with one species of tree yet damage another.

In addition to the four major species, other species will be evaluated in supplemental studies, the number depending on availability of trees and allowable planting time. Nitrogen-fixing trees will be interplanted with other biomass species to study impacts upon the soil nutrient reserve. Nitrogen fertilizer has been found to contribute over 20 percent of the total energy input of some biomass plantings. Thus, this particular study will yield valuable information toward developing favorable energy balances with woody biomass crops.

Taken together, the studies will lead toward an understanding of the potential and the environmental implications of woody biomass production in the Midwest.

Analytical Chemistry Helps Find Answers to Pollution Problems

R. S. VOGEL and L. G. HANSEN

An analytical specialist at a major chemical corporation recently commented, "We are reaching the point in analytical development where we will be finding everything in everything." Though made tongue-in-cheek, this remark may not be too far from the truth. Today, analytical chemists use many techniques to determine minute but critical levels of chemical pollutants in the environment.

Sources of these pollutants include food and feed additives, drugs, pesticides, and industrial chemicals. Many such substances, some of them toxic, enter the environment through air, water, and soil, and eventually reach the food chain. They range from complex polycyclic compounds to relatively simple salts or chelates of metallic elements such as arsenic, beryllium, cadmium, chromium, copper, lead, mercury, and nickel.

In the near future we will probably be exposed to even greater concentrations of these agents. The trend seems clear because the use of chemicals is increasing. Moreover, in some cases their effects are amplified by recycling, which has become an economic and environmental necessity.

R. S. Vogel is associate research chemist, Institute for Environmental Studies, and research associate, College of Veterinary Medicine. L. G. Hansen is associate professor of veterinary bioscience.

Municipal wastes studied

The University of Illinois is actively investigating pollutants on several fronts. A number of studies are focused on heavy metals in municipal sewage sludge.

Disposal of this waste has become a major problem. The use of digested sludge as a soil amendment may provide a partial solution while taking advantage of a valuable resource. For the past ten years University agronomists have successfully used secondary sewage sludge to fertilize cropland and to reclaim strip-mined land.

Substances accumulated in this sludge from wastewater purification may, however, have adverse effects on the environment. Researchers from the Colleges of Agriculture and Veterinary Medicine are now studying the possible relationship of toxicants to the food chain. The project is conducted in cooperation with the Metropolitan Sanitary District of Greater Chicago and the U.S. Environmental Protection Agency.

In other projects, Professor Thomas Hinesly in Agronomy is directing studies of the transfer of heavy metals from sludge-amended soil to grain crops to food animals. Professor Donald Bray in Animal Science and Professors Joseph Dorner, Joseph Simon, and Larry Hansen in Veterinary Medicine are extending this investigation to the effects of accumulated sludge contaminants in food animals. Under the direction of Professor Paul Fitzgerald, also of Veterinary Medicine, heavy metals and pathogens from municipal sewage sludge are being systematically investigated.

Analytical techniques used

All of these investigations rest on results from a multitude of chemical analyses. Methods range from the relatively simple determination of nutrient elements in bulk samples to analysis for trace and ultratrace heavy metals in microsamples. The latter type of analysis requires expertise to develop instrumentation and methodology beyond the state of the art.

One of the most versatile and extensively used analytical techniques is atomic absorption spectroscopy. This technique is capable of determining most of the elements of the periodic

table at concentrations ranging from percent levels to fractional parts per billion.

For analysis, a very small sample portion is converted into an atomic vapor and maintained at a high temperature. Absorption of light by the vapor is then measured at a specific wavelength chracteristic of the element to be determined. The degree of absorption is proportional to the concentration of that element.

The basic principles of atomic absorption spectroscopy have been known since 1859. In that year Kirchoff and Bunsen first reported on the spectral characteristics of radiant energy emitted or absorbed by particles of metallic salts introduced into a flame. The specific positions of discrete lines produced in the spectra correlated with the presence of the corresponding elements.

The birth of atomic absorption spectroscopy as an analytical technique, however, was delayed until 1955, when Sir Allen Walsh in Australia applied the basic principles to the development of an integrated instrumental system. The first primitive commercial instruments appeared in the early 1960's. Since that time, equipment and methods for atomic absorption spectroscopy have proliferated more rapidly than for any other analytical technique.

Inevitably, its capabilities were occasionally distorted. Chemical analysts inadequately trained in physics and chemistry often failed to detect problems affecting analytical results. Moreover, erroneous statements in advertising and in the published literature led the uninformed into hazardous situations.

However, atomic absorption spectroscopy has survived its growing pains and today is the primary method for trace analysis for heavy metals in biological and inorganic materials.

Cadmium detection

During the past few years concern about cadmium, one of the more toxic heavy metals, has increased. Research indicates that cadmium normally absorbed through food and environmental exposure becomes concentrated in the liver and kidneys. Robert Cousins at Rutgers found that increases in dietary cadmium levels in swine and chickens correlated positively with anemia and other less defined effects.

In controlled experiments to date, relatively large amounts of cadmium had to be added to the diets of research animals because of the limited sensitivity of available analytical methods. Another reason for using large amounts was that a specific cadmium-binding protein in the liver, kidney, and intestinal mucosa delays the progress of cadmium poisoning.

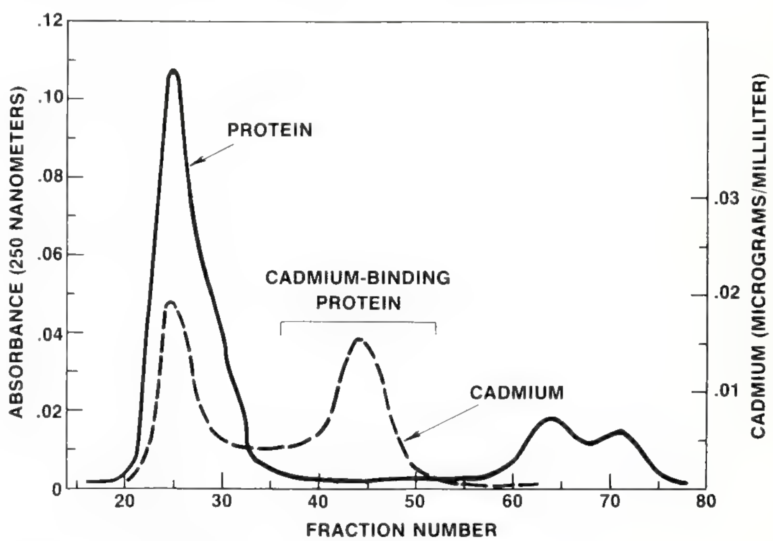
Now, however, cadmium can be determined at concentrations only one-thousandth as great as in the past. Development of a new analytical facility at the College of Veterinary Medicine made this advance possible. With a microfurnace atomic absorption technique, we can determine levels of less than 0.0001 part per million in a 0.02-milliliter sample solution. This means that as little as 0.002 nanogram (2 trillionths of a gram) of cadmium can be detected and measured, instead of the 2 nanograms by conventional methods.

With this degree of sensitivity now available, controlled experiments are possible at dietary cadmium concentrations similar to those occurring when sewage sludge is added to the soil.

We are currently reevaluating the effect of dietary cadmium on the formation of cadmium-binding protein in certain tissues, but at more realistic levels than before. Because this protein could not be observed at low cadmium concentrations with conventional techniques, it was assumed absent. With the new technique, however, its presence was confirmed.

Through a process called gel-filtration chromatography we obtained elution profiles of the soluble protein in sow liver. Figure 1 shows the relative molecular weights of the protein at which cadmium binding occurs. On the basis of this new information, formerly held conclusions will be revised to bring us another step closer to the truth.

What remains to be done is to correlate reliably reported concentrations of cadmium with effects that might be harmul to health. As Herbert Laitinen, editor of the journal *Analytical Chemistry*, has said, "... Refinements in analysis are frequently a prerequisite to progress in experimental science."



Results of gel-filtration chromatography of sow liver illustrate the minute amounts of cadmium that can now be determined. The animal received about 10 ppm dietary cadmium. Molecular weight of the protein decreases as the fraction numbers increase. The solid line corresponds to the concentration profile of protein and the dotted line to cadmium bound in the protein fraction collected. (Fig. 1)

Products for Control of Hog Waste Odors

D. J. WARBURTON, J. N. SCARBOROUGH, D. L. DAY, and A. J. MUEHLING

WHAT ABOUT all the new products designed to reduce odors and solids buildup in swine waste pits and lagoons? That's what many pork producers are asking as the result of an intensive campaign to market these products.

This question prompted a recent study of odor-control compounds at the University of Illinois. The purpose was to determine how effectively they reduced odors and liquefied solids in liquid manure pits under swine finishing buildings.

Products tested

Included in the experiment were 22 commercial compounds, which fell into four different categories:

Digestive agents (designed to control odor production and break down solids by biological means) — Sludge Away, Symbex, E-P Liquid Waste Control, Biozyme-Lo, Subdu, Micro Aid, Puritan Manure Treatment (PMT), Sanzyme, Enviro-Bac MD, Non Scents, Inter-Loc, Bio-Clean, Stable and Barn Odor Control (SBOC), MasterZyme D and L, Bacterial Waste Disposer (BWD), Fade, Envaid.

Deodorants (for neutralizing odorous gases or preventing their escape) — Air-Tite 771, Swine-Aid, The Nose Knows (TNK).

Oxidizing agent — Cairox.

Disinfectant — Tec II.

In addition, six other treatments were tested: waste oil, activated charcoal, wintergreen oil, chlorine, mechanical aeration, and an experimental product formulated at the University of Illinois. All the main types of odor control except feed additives were represented in the tests.

How experiment was conducted

For the experiments, 55-gallon drums were used as models of manure pits. Enough manure was put into each drum at the beginning of the tests to represent one month's accumulation. It was then treated with odor-control preparations according to the manufacturers' directions. During the following month or more, manure was added daily to simulate the amount from finishing hogs. Additional odor-control treatments were made as specified by the manufacturers. Three trials were performed in 1977-78.

During each trial, small samples were removed from the drums every week to be evaluated by odor-sniffing panels in the laboratory. At the end of a trial the contents of the drums were completely mixed and samples were taken to determine a full spectrum of solids as well as the degree of liquefaction. The amount of surface crusting was also observed.

Standard procedures were followed in odor evaluation. Samples of untreated manure and plain water were included with the samples of treated manure. To prevent visual comparisons, samples were contained in black bottles covered with gauze. The bottles were identified with three-digit random numbers, eliminating any unconscious bias by the panelists.

Odor was rated for strength and acceptability on a 0-10 scale. Each weekly panel for the first two trials was made up of 40 to 50 people. A smaller group was used in the third trial so that variations among panelists could be studied.

Performance disappointing

On the basis of statistical analysis of responses from a broad cross section of panelists, the overall performance of the commercial compounds in reducing odors was disappointing.

A possible cause for the masking agent's ineffectiveness was that it was broken down by bacteria. The oxidizing agent may have been more effective at higher dosages — and therefore greater costs — but the reaction rates for oxidizing ammonia and similar compounds are generally slow. Consequently odorous gases may still be released.

The chemicals that reduced odors most effectively were chlorine and the University experimental product. The most effective treatment of all was mechanical aeration.

Solids breakdown was not greatly improved by any of the compounds — even those designed primarily for that purpose. There was little difference between treated and untreated samples. Swine-Aid, chlorine, and the University experimental product were the most effective materials for controlling surface crusting.

Cost analysis

Based on bulk buying, costs per hog year ranged from $.02 to $12.40 for the commercial compounds. Tec II could cost as little as $.75 if purchased in large enough quantities. Swine-Aid cost about $.63. Aeration power costs were estimated at $4.52, although capital and maintenance costs could raise that figure to about $5.00.

At the rates used in these trials, chlorine cost $23.45 per hog year. The University product, for which we used laboratory-grade chemicals, cost from $11.74 to $23.48, depending on dosage. Even with bulk purchases of commercial-grade chemicals, the minimum dosage would still cost about $6.00. Thus the two most effective materials — chlorine and the experimental product — are too expensive for general use.

D. J. Warburton was formerly a visiting Fulbright-Hays Scholar; J. N. Scarborough, D. L. Day, and A. J. Muehling are faculty members of the Department of Agricultural Engineering. S. E. Curtis and A. H. Jensen of the Department of Animal Science also contributed to this project. It was supported in part by the Illinois Pork Producers Association.

Pigs Know Best-Turn on the Heat When They Need It

Pig roots paddle to turn on heat lamps. (Fig. 1)

R. K. BALSBAUGH and S. E. CURTIS

When kept outdoors, pigs will seek protection from inclement weather and sometimes even make shelters for themselves. In most confined housing, however, young pigs cannot move to a better niche when they become uncomfortable. Nor do they have access to materials for modifying their own environment. Except for huddling to conserve body heat, a group of chilled pigs must depend on the manager to provide a tolerable environment.

In a chilly house young pigs may not convert feed to weight gain efficiently, and they may become susceptible to disease. During cold weather, environmental temperature in enclosed farrowing and nursery facilities can be kept relatively uniform over space and constant over time. But such an approach deprives young pigs of the chance to select an environment more comfortable than the one chosen by the manager. Providing more heating, cooling, uniformity, or constancy than necessary may also be uneconomical in this era of high energy prices.

Operant conditioning

During the last few years the Department of Animal Science has tried to determine whether young pigs in groups can control their own thermal environment. The research is based on the principle of operant conditioning, by which an animal learns to operate some device in order to receive a reward. With water as a reward, pigs readily learn to operate demand waterers, which are widely used in the swine industry.

A British study found that chilled pigs held singly will learn to operate a switch to receive a radiant-heat reward. It was not known, however, whether pigs held in a group, as is commonly done in pork production, would operate a supplemental-heat switch effectively.

Experimental methods

Our experiments have been carried out in a room where environmental temperature can be closely controlled. A group of four pigs is held in a solid-sided pen with a slotted metal floor measuring 2.3 × 4.7 feet. A self-feeder and nipple demand waterer are located at one end of the pen. At the other end two 250-watt infrared lamps are suspended 2 feet above the floor. Beneath these heat lamps is a switch device that the pigs can operate to activate the lamps.

The device, which consists of a hinged paddle scavenged from a bowl-type demand waterer, is connected to a microswitch. When a pig roots the paddle (Fig. 1), the microswitch closes for an instant, and an electrical current passes to a time-delay relay. The relay in turn controls current flow through the heat lamps.

The period that the relay remains closed, and thus the period that the heat lamps stay on, can be varied. When the lamps are on, attempts to operate the switch have no effect. These attempts are monitored, however, by a strip-chart recorder. Periods of heat-lamp activation are also recorded.

Initial trials

The first experiment consisted of eleven trials of 9 days each. Preparatory to a trial, four 4-week-old littermates were weaned and immediately placed in the experimental pen. Room temperature was set at 80°F the first day, 70° the second, 55° the third, and 40° the last day.

The pigs readily learned by themselves to operate the supplemental heat switch during this learning and postweaning adjustment period. The actual trial was then started.

The 9-day period was divided into three successive 3-day subperiods. In each subperiod the room temperature varied systematically from day to day among three temperatures — 40°, 55°, and 70°F. The time-delay relay was set so that when the switch was hit, the heat lamps went on for 1 minute in five of the trials, 3 minutes in three trials, and 6 minutes in three trials.

The total number of minutes that the lamps were on each day was related inversely to room temperature, whether the system was set to deliver

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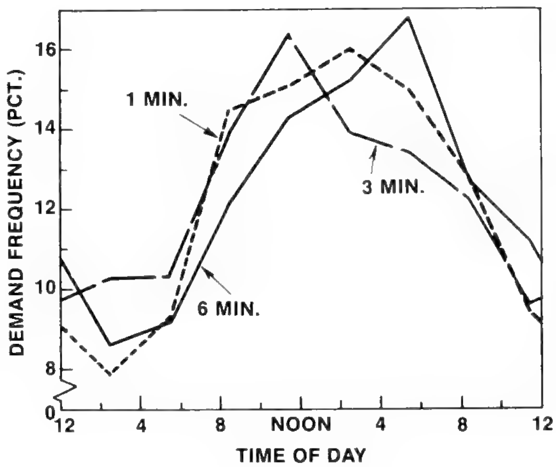
R. K. Balsbaugh is a graduate assistant and S. E. Curtis, associate professor of animal science.

supplemental heat for 1, 3, or 6 minutes. The relation between environmental temperature and heat-lamp activation followed a straight line, with approximately twice as much supplemental heat being called for at 40° as at 70°F (Fig. 2). This finding indicates that young pigs in small groups will operate a switch in an orderly way to obtain short periods of supplemental heat.

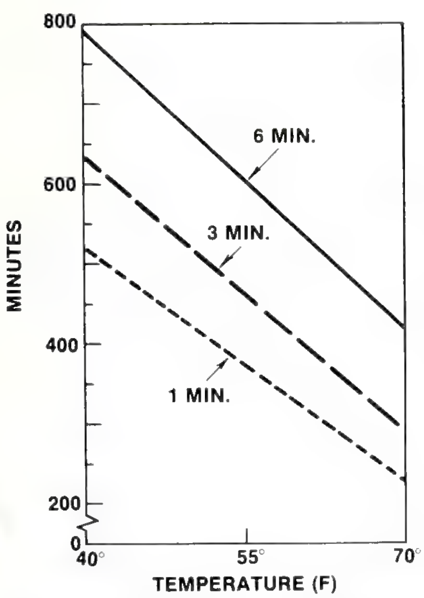
The pigs would have had to operate the switch six times as often at the 1-minute setting as at the 6-minute setting to obtain the same total daily supplement. Although they tended to do this, compensation was not complete. Total daily supplement was less at the 1- and 3-minute settings than at the 6-minute setting (Fig. 2).

This finding suggests either that a group of pigs is limited in its ability to meet supplemental heat needs at certain heat-period settings, or that the group's need for supplemental heat varies with the setting.

A third result of the initial study was that frequency of demand depended on time of day. Demand was roughly twice as great in the middle of the afternoon as in the early morning (Fig. 3). This daily cycle occurred regardless of environmental temperature or heat-period setting, and despite the fact that environmental temperature and light intensity were constant during a 24-hour period.



Percent time that heat lamps at three settings were on during a 24-hour period. Percentages, which were determined from eight 3-hour subperiods, are averages for 9 days. Demand peaked in the afternoon. (Fig. 3)



Time that heat lamps at three settings were on during a 24-hour period. Data for each setting are averages for 3 days at each room temperature. (Fig. 2)

We then conducted auxiliary trials to learn whether such a daily cycle would persist under different light and dark regimens. Two schemes were tried: (a) light from 6 a.m. to 6 p.m. and dark the next 12 hours, and (b) dark from 6 a.m. to 6 p.m. and light the next 12 hours. For these trials the heat period was set at 3 minutes only, but the same room temperatures, namely 40°, 55°, and 70°F, were used as in the initial study.

Regardless of regimen, the daily demand cycle was similar in frequency to that observed in the first experiment: demand was roughly twice as great at 3 p.m. as at 3 a.m. This consistency in the daily cycles supports the idea that grouped pigs will call for supplemental heat when they need it. Apparently pigs require less heat during extended rest periods, perhaps because they usually huddle as they rest.

The fact that the pigs, in effect, called for a cooler temperature at night than in the day may have the practical application of reducing supplemental heating costs.

Further trials

According to preliminary observations of pigs' behavior, there is a close correspondence between activity and heat-demand frequency for individual pigs as well as for the group. Just as demand frequency varied with time of day and environmental temperature, so did general activity. We have begun another study to eliminate the possibility that the pigs hit the paddle frequently in mid-afternoon simply because they are more active during the day than at night.

In our current research, room temperature is set at 80°F. Heat from six lamps is delivered to the pigs unless they operate a switch to deactivate the lamps for a 3-minute period. A rheostat controls the heat output at a low, medium, or high level. Early results indicate that the pigs turn off the lamps one and a half times as often at the high setting as at the low.

Interestingly, the heat was turned off at night about as often as it had been turned on by day in the initial study. Thus, the curves for frequency of deactivation over a 24-hour period would look like the curves in Figure 3 turned upside down. By deactivating the lamps the pigs made their environment cooler at night, even though they had to operate the switch oftenest when they were resting.

In future studies we will try to determine how groups of pigs that have control over their thermal environment during cold weather perform in comparison with pigs that are provided supplemental heat by more conventional means.

Five Planter Meters Tested For Damage to Soybean Seed

MARVIN R. PAULSEN and W. RALPH NAVE

SUCCESSFUL soybean production depends partly upon optimum plant populations. But severe damage to seeds during planting may lower the germination rate so much that the necessary populations cannot be established.

Seed damage may possibly be caused by the planter meter, the device that regulates the spacing and flow of seeds from the hopper to the furrow openers. To explore this possibility, we recently tested five different types of meter.

Planter meters

For the tests, the meters were set at a normal seeding rate of about 160,000 seeds per acre. Each meter was adjusted according to the operator's manual. Planters were operated in a stationary position by placing a drive wheel on electrically powered rollers which simulated normal field-planting speeds. Beeson, Williams, and Wells varieties were used for each test. Beans were collected in burlap bags at the furrow-discharge point.

These are the planter meters tested:

Single-run feed cup on a John Deere series 7000 Max-Emerge planter. The metering assembly for this planter consists of internal flutes placed in the inner and outer radii of a device shaped like half of a hollow doughnut. Seeds are metered through the device as it rotates.

Air drum on an International Harvester (IH) series 400 Cyclo planter. This meter uses a fan to pressurize a centralized hopper and drum. Seeds flow by gravity from hopper to drum, where air pressure holds the seeds in a row of holes located around the drum circumference. When the drum has rotated past an external cutoff wheel that blocks the holes, the pressure equalizes and the seeds drop into the discharge manifold. High-velocity air then moves each seed through a tube to the furrow.

Fluted roller on an IH series 510 grain drill. The fluted rollers were open about 0.4 inch and were run with the slow-speed drive recommended for soybean metering.

Horizontal plate on an IH series 58 planter. Cells in the plate of this meter move beneath a spring-loaded cutoff pawl, which wipes excess seeds from the top of the plate. A spring-loaded knockout device extracts seeds from the cells as they pass above the delivery tubes. The seeds then drop by gravity through the tubes into the furrow opener.

Air disk on a White series 5400 Plant/Aire planter. The metering disk rotates vertically in a pressurized air chamber under each hopper. Seeds picked up from the hopper are held against the disk by air pressure. When the disk rotates past a cutoff device, the seeds drop into delivery tubes.

For comparison we dropped some seeds 27 feet onto a steel plate. Control samples were taken directly from the seed bags. All tests were replicated three times. Although the beans were tested at three moisture levels, the results from only the medium range, 10.5 to 13.3 percent, are reported here. (More detailed results appear in Paper No. 77-1004, published by the American Society of Agricultural Engineers.)

Seed damage evaluations

The extent of damage caused by the planter meters was determined from several tests: germination percentages, tetrazolium tests for potential germination and for damage, and percentage of splits and seedcoat cracks.

Germination tests. The Illinois Crop Improvement Association conducted four germination tests:

Warm test — 100 seeds were placed on moist paper tissue. Temperature was maintained at 78°F and relative humidity at 95 to 100 percent for six days.

Cold test — 100 seeds were planted in a soil-sand mixture and kept at 50°F for seven days. Conditions for the warm germination test were then maintained for another four days.

Accelerated aging test — 100 seeds were heat treated at 104°F for two days. This treatment was followed by warm germination conditions for six days.

Accelerated aging cold test, the most severe test of all — 100 seeds were exposed to temperatures of

Marvin R. Paulsen is assistant professor of agricultural engineering; W. Ralph Nave, research leader, USDA Science and Educational Administration, Agricultural Research, Urbana. Mention of trade names in this article does not constitute a guarantee by the University of Illinois or the USDA and does not imply approval of a product to the exclusion of other suitable products.

104°F for 32 hours, 50°F for seven days, and warm germination conditions for four days.

Tetrazolium tests. These indicate the degree of seed damage and the potential for germination. First we premoistened 100 seeds for 12 hours, then soaked them 5 to 7 hours in a 1-percent tetrazolium solution. Healthy tissue turned pink and damaged tissue a dark purple when the seeds were immersed. Dead tissue remained white. If embryonic parts stay white, the seed will not usually germinate.

Tetrazolium germination potential was defined as the percentage of seeds having no white tissue after immersion in the solution, or amounts so negligible that the seed was still considered germinable. Tetrazolium damage was defined as the percentage of 100 seeds having some white, that is nonliving, tissue after immersion. The presence of nonliving tissue indicated that some damage had occurred.

Splits and seedcoat cracks. To determine the percentage of splits we screened 200-gram samples over a 10/64 × 3/4-inch slotted sieve. Percent splits was defined as the weight of material passing through the sieve divided by the original weight, and multiplied by 100.

To calculate seedcoat crack percentages we first removed all splits and then soaked 500 of the remaining whole beans in a 0.1-percent solution of sodium hypochlorite (Clorox) for 5 minutes. Soybeans with cracks in the seedcoat readily absorbed the solution and swelled to two or three times their normal size. Enlarged seeds were easy to separate from undamaged seeds, which were not swollen. The percentage of seedcoat cracks was determined from the ratio of the number of swollen beans to the original sample size.

Table 1. — Soybean Seed Damage Evaluations Averaged for Three Varieties at 10.5- to 13.3-Percent Moisture Content

Treatment	Germination test				Tetrazolium		Splits	Seedcoat cracks
	Warm	Cold	Accel. aging	Accel. aging cold	Potential germ.	Damage		
					percent			
Control	87.1	62.6	30.3	1.1	96.6b*	32.7	0.38a	13.7
Feed cup	87.6	60.8	24.7	1.4	96.7b	30.8	0.43a	12.7
Air drum	89.1	63.8	33.3	0.8	96.9b	29.4	1.00bc	13.4
Fluted roller	88.3	60.1	34.1	0.9	96.7b	32.6	0.56a	12.8
Plate	85.4	57.6	26.6	1.4	95.8a	31.8	1.22bc	11.7
Air disk	87.8	62.3	42.7	1.6	96.4b	29.9	0.52a	12.7
Drop, 27 ft.	84.7	61.3	33.7	1.9	95.8a	32.7	0.85b	13.7
LSD	..	..	..	..	0.8	..	0.24	..

* Numbers with the same letters within columns did not differ significantly at the 5-percent level, based on the LSD test for differences between means.

Table 2. — Soybean Seed Damage Evaluations Averaged by Varieties for All Treatments

Variety	Germination test				Tetrazolium		Splits	Seedcoat cracks
	Warm	Cold	Accel. aging	Accel. aging cold	Potential germ.	Damage		
					percent			
Beeson	87.1	44.5a*	29.9	0.6a	96.2	30.9	1.02b	14.3b
Wells	87.4	76.6c	39.2	1.2a	96.1	31.1	0.59a	11.0a
Williams	86.9	62.5b	27.5	2.1b	97.0	32.3	0.52a	13.6b
LSD	..	5.4	..	0.9	..	..	0.19	0.8

* Numbers with the same letters within columns did not differ significantly at the 5-percent level, based on the LSD test for differences between means.

Seed damage results

The mean for warm germination percentages ranged from 84.7 for the drop test to 89.1 for the air drum planter (Table 1). Percentages for the cold test were much lower, ranging from 57.6 for the plate planter to 63.8 for the air drum. Differences among the treatments were not statistically significant for any of the germination tests at the 5-percent level of probability.

The only tests showing significant differences among treatments were those for tetrazolium potential germination and percentages of splits. Potential germination was lower in samples from the plate planter and the drop tests than from the other five treatments.

Percentage of splits was 1.2 percent for the plate planter and 1 percent for the air drum. These figures were significantly higher than the 0.85 percent resulting from the drop test. Splits for the other planters and the control were all significantly lower than 0.85 percent.

Seed damage was found to be more closely related to soybean variety than to planter meters (Table 2). Cold germination percentage for Beeson was 44.5, which was significantly lower than for Williams and Wells. Beeson also had significantly more splits than the other two varieties, while seedcoat crack percentages were higher in Beeson and Williams than in Wells. Warm germination percentages did not vary significantly among varieties.

We concluded that all five of the planter meters tested in our study are satisfactory for planting soybeans. The amount of damage to the seeds as they passed through the meters was not great enough to significantly reduce germination. Even splits as high as 1.2 percent did not cause a statistically significant drop in percentages for the warm and the cold germination tests. We did find that Beeson was more easily damaged than the other two varieties.

Growing Herbs in the Home Garden

JOSEPH S. VANDEMARK and WALTER E. SPLITTSTOESSER

HERBS have been prized since ancient times, with their healing powers sometimes being considered as magical. Today gourmet cooks continue to value them for the zest and interest they add to food.

Most cooks prefer fresh herbs, but will substitute frozen or freeze-dried herbs when fresh ones are not available. Herbs are mostly water when fresh, so drying greatly intensifies their flavor. Only one-fourth to one-third as much of a dry herb as of a fresh herb is needed to give similar results.

Culinary experts classify herbs into two groups — robust and fine. Robust herbs have a strong flavor and need to be cooked. Fine herbs may be eaten uncooked in salads or sprinkled over a cooked dish. If used in cooking, they should be added during the last few minutes so their delicate flavor is not destroyed.

Where herbs can be grown

Growing herbs is an interesting endeavor for gardeners who want to do something special and for those with limited space. Herb gardens may be formal or informal, or limited to individual specimen plants. Gardens as small as 5 square feet may be located near doorways or along walkways, incorporated into the patio or terracing, or worked into a rock garden. Some herbs can be grown successfully indoors for use throughout the year.

Herbs will grow well in any soil that is suitable for vegetables. The soil should be moderately fertile and well supplied with organic matter. Good drainage is essential. If your soil is poorly drained, grow herbs in raised beds. Insects and diseases are not serious problems on herbs in Illinois.

Joseph S. Vandemark is professor of horticulture; Walter E. Splittstoesser, professor of plant physiology, Department of Horticulture. Photographs are by Joseph S. Vandemark II.

Propagation

Dill, anise, caraway, coriander, parsley, savory, basil, and sweet marjoram are well adapted to direct seeding. Rosemary, thyme, and sage can also be started from seed, but they are grown most successfully from plants or rooted cuttings. Other herbs that can be grown from rooted cuttings include mint, basil, oregano, savory, and sweet marjoram.

To root cuttings, first fill a pot with "builders' sand" (a coarse, sharp-cut material), put it in a saucer to collect water, and thoroughly moisten the sand. Snip the cuttings; remove the leaves from the lower inch or two of stem; and place the cuttings in the moist sand. For faster and surer rooting, dust the ends of the stems with a rooting agent or hormone before putting them in the pot.

An inverted plastic bag can be placed over the top of the plant container, forming a miniature "greenhouse" to encourage rooting. The cuttings should be kept warm and moist. Remove excess water from the saucers to maintain an air supply for the developing roots.

Root division is the third method of herb propagation and can be easily done with the mints, thymes, and chives. The plants are simply dug up, divided, and planted back into the soil or containers.

Some common herbs in Illinois

Basil is a green or purple, tender, annual aromatic plant with a spicy odor and flavor. It grows 12 to 24 inches tall. There are many variations in plant habit and leaf shape.

Basil can be grown from either seeds or cuttings. Plants should be 8 to 12 inches apart. To keep the plants actively growing, remove all the flowers before the seeds mature.

This herb can be used fresh or dried for winter. Many gardeners cut back a plant or two and put them in pots in the house for winter use.

Chives are perennials. The small, bulbous plants grow in clumps 8 to 12 inches high. They are usually propagated by dividing the clumps in early spring, keeping four to six bulblets for each new start. Chives should be divided every two to three years to prevent overcrowding. They may also be started from seed in early spring.

The tender leaves or the entire plant may be harvested whenever desired during the season. The bulbs are not used. Most gardeners use the leaves fresh or chop and freeze them. Many gardeners dig a clump of chives in late January, put them in a pot, and bring them into the house for fresh use during the winter.

Dill is a tall, self-reseeding annual with feathery leaves. It is easily grown from seed. Although it will usually grow in all types of soil, it prefers a well-drained, fertile soil. After the seedlings have established themselves (1 to 2 inches high), they need to be thinned to 6 to 9 inches apart. Ultimately the plants should reach a height of 3 to 3½ feet.

Method of harvesting depends upon how you plan to use the herbs — as flower heads (which are preferred for pickles), dill weed, or seed. For flower heads, cut the stems with the flowers in full bloom. Tie the stems in bunches and let them dry in the dark. For seed, allow the flowers to mature (usually two to three weeks after the blossoms appear) before harvesting the plants. Hang the plants in bunches with papers spread beneath them to collect the seed. Dill weed is prepared by bag-drying young foliage before the flower heads appear. It is used as a fine herb in salads, omelets, and herb blends.

Parsley is a biennial that may also be grown as an annual under Illinois conditions. It is the most widely grown of the herb plants. There are two distinct types: curled and flat-leaf or Italian parsley.

Basil.

Rosemary.

Sage.

Thyme.

Parsley seeds can be planted in the spring in cold frames, in window boxes, or directly in the garden. When sown in the garden, seeds should be planted early, at the rate of 10 to 15 seeds per foot of row, and covered with ¼ inch of fine soil. The seedlings should be thinned to 4 to 6 inches apart.

The green leaves may be harvested any time during the growing season. Fresh or dried leaves are used as a garnish in soups, vegetables, salads, meats, and poultry. The roots, finely chopped, are used in soups. Many cooks use parsley because of its unique ability to blend the flavors of other herbs. Parsley may also be used as a base for a fine herb mixture with thyme, sweet marjoram, basil, rosemary, summer savory, and a small amount of sage. The combination acts as a unit, rather than the expression of a single herb flavor.

Rosemary is a small, evergreen shrub not winterhardy under Illinois conditions. The narrow leaves have a spicy odor that makes rosemary valuable for its scent as well as its flavor. Rosemary plants may be purchased from greenhouses or garden centers. Plants may also be propagated from stem cuttings or by planting seed indoors in very early spring. Some gardeners pot a rosemary plant from the garden in the fall and bring it into the house for winter use and spring stem propagation.

When transplanting rosemary to the garden in the spring, allow a foot or more between plants. The growth can be pruned back several times a season for drying or fresh use.

Sage is widely cultivated in Illinois. It is a shrubby perennial plant that may grow as tall as 24 inches. Plants may be propagated from seeds, stem cuttings, or crown divisions. Transplant seedlings when they are 3 to 4 inches high, spacing them 15 to 18 inches apart. Prune plants severely in early spring to prevent flowering.

For use, cut 6 to 8 inches of top growth from the plants at least twice during the growing season. After washing and drying the stems, strip off the leaves and place them in closed containers for winter storage.

Thyme is a small, low-forming shrublike perennial that grows to a height of 4 to 8 inches in Illinois. Common thyme may be used fresh or dried. Most thyme growers start new plants every three to four years. Thyme is best propagated from seed indoors or by dividing the mature plant. Transplant when the plants are 2 to 3 inches high, spacing them a foot apart in the row. A well-drained, sunny location is essential.

When the plants start to bloom, cut the flowering tops. The harvested thyme should be spread on a fine screen or newspapers in a dark, well-ventilated room to dry. After the plants are thoroughly dry, strip off the leaves and flowering tops and store them in a closed container.

Day Length Determines Bulb Size And Time of Maturity in Onions

MOONESHWAR RAMTOHUL and WALTER E. SPLITTSTOESSER

Many people think that they can't grow large yellow onions in Illinois. However, they can do it if they give the plants a good start.

All onions require long days for bulbing, although the critical day length for initiation of bulbing may vary among cultivars. Regardless of plant size, bulbing begins when the critical day length is reached. If plants are small at that time, the bulbs will be small too. Thus, for large onions, seedlings need to be started early and also transplanted early in the season.

Three cultivars tested

In recent experiments, seeds of Yellow Sweet Spanish, Yellow Bermuda, and Granex were sown in the greenhouse on January 15. Seedlings were transplanted in the field April 15 and 30. Seeds were also planted directly in the field on April 15. Plants were thinned to a spacing of 4 inches in the row.

Bulbs were considered to be mature when 75 percent of the tops had fallen over, and were harvested at that time. The plants were dried under cover. When the roots and tops were dry, the tops were cut off, and the cleaned bulbs were measured.

Maturity and yields

The age of the plant had little influence on maturity of Yellow Bermuda and Granex, since seeds and 3-month-old seedlings produced mature bulbs within 6 days of each other (Table 1). Yellow Sweet Spanish was very erratic in maturity, with 60 percent of the plants being harvested after 135 days and 20 percent 160 days after direct seeding. The rest of the plants remained vegetative, and because they grew under conditions that were not favorable for bulb formation, they developed new leaves without maturing.

Mooneshwar Ramtohul is a former graduate student; Walter E. Splittstoesser is professor of horticulture.

Table 1. — Yield and Number of Days From Field Planting to Maturity[a]

Time of planting	Yellow Bermuda		Granex		Yellow Sw. Spanish	
	Days	Lb./A.	Days	Lb./A.	Days	Lb./A.
Direct-seeded 4/15	81	1,200 a	81	1,100 a	135-150	10,000 a
Transplanted 4/15	75	8,500 b	75	8,600 b	100	21,200 c
Transplanted 4/30	81	1,900 a	81	1,500 a	105	13,400 b

[a] Means in a column followed by the same letter are not significantly different at the 5% level of probability.

Yellow Sweet Spanish consistently produced the highest yields (Table 1). There was no significant yield difference between the other two varieties. Highest yields for all varieties resulted from transplanting on April 15, while the lowest yields resulted from direct seeding.

Yellow Bermuda and Granex plants that were direct-seeded or were transplanted late produced large numbers of bulbs smaller than 2.5 centimeters or about 1 inch in diameter (Table 2). Yellow Sweet Spanish, however, did not produce many bulbs this small, regardless of planting date. For all three cultivars, early transplanting resulted in the highest yield of bulbs over 5 centimeters in size.

Table 2. — Interacting Effects of Planting Date and Cultivar on Bulb Size

Cultivar and planting date	Size of bulb, cm.[a]		
	1-2.5	2.6-5	>5
	percent of bulbs		
Yellow Bermuda			
Direct seeded 4/15	88 c	12 a	0 a
Transplanted 4/15	5 a	71 c	24 b
Transplanted 4/30	71 b	29 b	0 a
Granex			
Direct seeded 4/15	92 c	8 a	0 a
Transplanted 4/15	12 a	58 c	30 b
Transplanted 4/30	82 b	18 b	0 a
Yellow Sweet Spanish			
Direct seeded 4/15	1 a	90 c	9 a
Transplanted 4/15	0 a	11 a	89 c
Transplanted 4/30	0 a	66 b	34 b

[a] Means in a column followed by the same letter are not significantly different at 5% level of probability.

Reasons for variations

The critical day length for bulbing is not so long for Yellow Bermuda and Granex as for Yellow Sweet Spanish. Thus, plants of the former two varieties were still small when the critical day length was met, especially if they had been direct-seeded or transplanted late, and the bulbs were also small at maturity. Yellow Sweet Spanish produced higher yields because the plants grew for a longer time and were larger when the bulbs began to form.

The scale leaf formation in the bulb onion is generally induced by a long photoperiod, whereas thickening of this scale leaf, which influences the size of the bulb, is mainly due to the energy from photosynthesis. Thus, plants with a larger leaf area at the time of scale leaf formation will have more photosynthates available for storage than plants with a small leaf area; and this results in larger bulbs.

Four Receive Funk Awards

Four College of Agriculture staff members were cited for "outstanding performance and high achievement" in the ninth annual Paul A. Funk Recognition Program, held in Urbana on March 9. Each citation was accompanied by a cash award. Funds for this program are provided by the Paul A. Funk Foundation of Bloomington.

The major achievements of the award winners are briefly summarized in the following paragraphs.

Richard Lawson Bernard

An outstanding plant geneticist, Dr. Bernard has developed soybean varieties that are now grown on 50 percent of the soybean acreage in Illinois as well as on substantial acreages elsewhere. The estimated value of these varieties in 1978 was nearly a billion dollars in Illinois and even more outside the state.

Among the varieties he developed are Williams, Wayne, Woodworth, and the newly released Franklin, which is resistant to cyst nematode. Currently he is developing varieties resistant to brown stem rot and other diseases.

In research on qualitative genetics in soybeans, he has determined the inheritance of semideterminate plant growth, which is important for lodging resistance. He and a fellow scientist recently reported a gene that provides about 10 percent outcrossing instead of the normal rate of less than 1 percent. This was the first indication that large-scale production of soybean hybrids may be possible.

He is on the advisory boards of the Illinois Crop Improvement Association and Illinois Foundation Seeds, and for more than 20 years was chairman of the Soybean Genetics Committee.

Marvin Pierce Bryant

Dr. Bryant is internationally known as a leader in the development of present day rumen microbiology.

He has been a pioneer in perfecting techniques for the isolation, identification, and characterization of individual bacterial species in the rumen. Using these techniques, he initiated the most comprehensive research program in the field on the physiology and nutrition of rumen bacteria. One discovery — that many major bacerial species require ammonia as the source of nitrogen — helped lead to the use of nonprotein nitrogen in ruminant diets.

A world authority on microbial methane production, Dr. Bryant has greatly augmented knowledge about methane formation and the interrelationships between methane and fatty acid production in the rumen.

He and his co-workers have refined techniques for simulating rumen activity in a continuous fermentor. They were the first to demonstrate how changes in dilution rate of the fermentation mixture affect protein synthesis and the formation of fermentation products.

Dr. Bryant has received the Borden Award for Research, as well as numerous other honors.

Lowell Dean Hill

Dr. Hill's research and public service programs on transportation, grain quality, and energy represent notable contributions to agriculture.

A leading scholar in transportation, he has provided government and industry with economic data on which to base decisions about such issues as allocation of railroad cars, replacement of Lock and Dam 26 on the Mississippi River, and user charges for barge traffic.

He was among the first to recognize the need for reforming outdated grain grades and standards. The changes in grades and discounts that he introduced have increased the accuracy with which farmers' prices reflect the value of grain to end users. With his testimony he influenced the formulation of the U.S. Grain Standards Act of 1976.

His studies of energy use by farmers and the grain industry have helped to retain agricultural priority in allocation of fuel supplies during periods of shortage.

In 1977 he was named Laurence J. Norton Professor of Marketing, becoming the first professor in the College of Agriculture to hold an endowed chair.

Arthur James Muehling

Professor Muehling has greatly strengthened the pork industry, primarily through his research and extension programs on swine housing.

Largely because of his influence, Illinois hog producers have been leaders in adopting confinement housing and slotted floors. As a result, they have been able to greatly expand production without increasing labor. The success of the Illinois program has prompted extension workers and producers in many other states to seek Professor Muehling's counsel.

Professor Muehling has also made major contributions to livestock waste management. He has been an advisor to the Illinois Environmental Protection Agency, the Illinois Institute for Environmental Quality, and the group drafting livestock waste regulations for Illinois.

In 1969 the National Pork Producers Association asked him to summarize all past research on swine housing and waste management. The report and fact sheets that he prepared have been widely used in this and other countries.

The Educational Award of the Illinois Pork Producers Association, presented in 1974, is one of the many honors he has received.

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FARM BUSINESS TRENDS

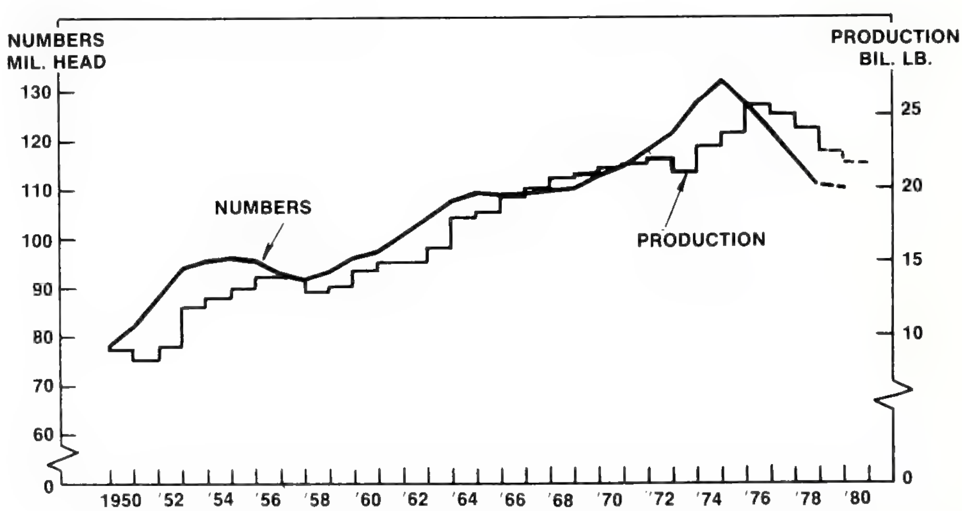
CHANGES in beef production lag behind shifts in cattle numbers (see graph). After herds increase, a drop in cattle prices takes several years to catch up with producers. The lag also affects consumers: beef prices go up only after a few years of liquidation.

Rapid increases in herds often lead to reduced beef production and vice versa. The sharp rise in numbers during 1951 was associated with a drop in production, and the decline in cattle numbers five years later was accompanied by a rise in production. During the 1960's, production did not overtake increasing cattle numbers for almost seven years.

Unlike the number-production swings of the 1960's, those of the 1970's have been unusually violent. Herds increased rapidly between 1971 and 1975, then fell off sharply between 1975 and 1979. Yet in spite of liquidation, beef production during 1975 increased only moderately. Because of the feed shortage after the disastrous 1974 corn crop, cattle were slaughtered at light weights. In 1976, however, production climbed to a record high with continuing rapid liquidation. The high levels held in 1977 and 1978 as herds declined.

There are indications that the liquidation phase has about ended. When this occurs beef supplies will decline. Projected production figures for 1980 are based on the assumption that cattle numbers will remain stable and that cattle will be fed to heavy weights. As numbers begin rising again during the 1980's, production will fall below the current level.

We can safely draw two conclusions from this analysis: cattle and beef prices will remain relatively strong for several years, and cow-calf producers will enjoy a competitive advantage over cattle feeders. Compared with the number of feeding facilities and the amount of concentrates available, the feeder cattle supply will be small. Cattle feeders will therefore bid aggressively for the limited supply of feeder animals. — *T. A. Hieronymus, professor of agricultural economics*



U.S. cattle numbers on January 1, 1950 to 1980, and beef production during each of those years.

Summer, 1979

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

This archway in the Temple of Hadrian at Ephesus, Turkey, was an ancestor of a window motif seen today in homes and other buildings in the United States (page 7).

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ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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R. G. Cragle ....Director

Sheila R. Wiley ....Editor

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AGRICULTURAL RESEARCH: A COMPLEX ENTERPRISE

During the past eight months I have spent a great deal of time talking with farmers, scientists, government administrators, and business leaders around the state. The point of these conversations was to find out how people feel about the future of agriculture and to let them know what we here at the Experiment Station are doing to meet their needs.

The people I spoke with hold many views in common. For example, they share the belief that the agricultural research team at the University of Illinois will play a vital role in the changes that must come, just as we have in past changes. People also realize that nearly every recent development in production agriculture must be weighed against the effects on the environment, the use of resources, and the benefits to the state and the nation. Not everyone was fully aware, however, that research becomes increasingly complex and expensive as we fulfill our obligations to the citizens of Illinois and to the international community.

Agricultural research has become more intricate and sophisticated over the years. To meet increasing demands, the research team will have to grow in its understanding of the problems. We will continue to strive for greater efficiency in agricultural production. But we must also take a close look at policy-related problems such as the continuing loss of agricultural land to nonagricultural uses, taxation of agricultural land, and erosion control. With carefully designed policies we will be able to go on working effectively for many years to come. — *R. G. Cragle*

Monitoring Soybeans for Foliar Diseases

Plots throughout Illinois help scientists learn about the incidence, severity, and location of diseases

J. K. PATAKY, S. M. LIM, E. G. JORDAN, and R. L. WARSAW

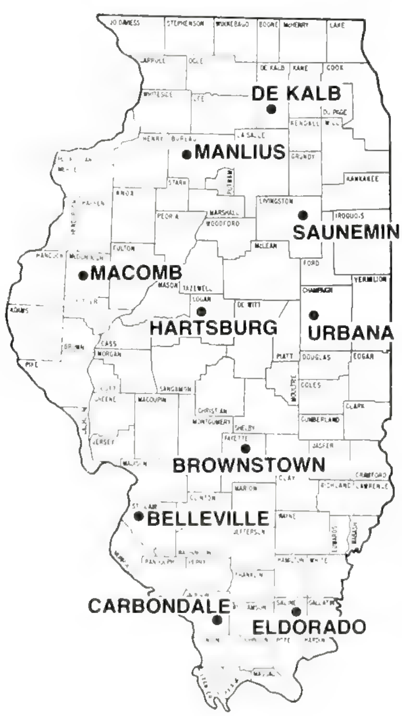
SOMEDAY, soybean pathologists will probably be able to forecast disease-risk situations and potential yield losses. To achieve this goal researchers are now gathering information from field plots especially designed for monitoring the natural occurrence of soybean diseases.

Two years ago a team from the University of Illinois began a statewide program to evaluate foliar diseases. Although quite new, the project has already supplied information that will help pathologists to identify the most prevalent diseases, breeders to determine the need for developing resistant cultivars, and farmers to select those cultivars best adapted to withstand the diseases found in their areas.

The program was begun in 1977 with the establishment of plots at DeKalb, Urbana, and Brownstown. Three replications of 14 cultivars planted in 3-row plots were arranged in a randomized complete block design. Last year the study included 16 cultivars at 10 locations (Fig. 1, Table 1).

Every two to three weeks from mid-June until harvest maturity, we examined the plants for incidence and severity of foliar diseases. Visual evaluations of the diseased part of the total leaf area were based on the Horsfall-Barratt rating system. Using these evaluations, we determined the percentage of disease severity in each 3-row plot. Plant growth stage, weather conditions, and nonfoliar diseases were also noted because this information will be needed to develop an accurate disease forecasting system.

J. K. Pataky is a graduate research assistant; S. M. Lim, assistant professor and USDA Science and Education Administration (SEA) plant pathologist; E. G. Jordan, assistant professor and USDA Animal and Plant Health Inspection Service plant pathologist; and R. L. Warsaw, a USDA-SEA research technician. All are in the Department of Plant Pathology. The authors wish to thank the cooperators who provided field space.



Soybean monitor plots in northern, central, and southern Illinois, 1978. The most prevalent leaf diseases were identified at these 10 locations. (Fig. 1)

Prevalent foliar diseases

As expected, foliar diseases and their severity differed by location, year, and cultivar (Tables 1 and 2). The most prevalent diseases were brown spot (*Septoria glycines*), bacterial blight (*Pseudomonas glycinea*), and downy mildew (*Peronospora manshurica*). Less common were bacterial pustule (*Xanthomonas phaseoli* var. *sojensis*), Phyllosticta leaf spot (*Phyllosticta sojaecola*), Alternaria leaf spot (*Alternaria* spp.), powdery mildew (*Microsphaera diffusa*), and soybean mosaic virus.

In northern Illinois bacterial blight spread to 49 percent of the leaf area towards the end of the 1977 season; brown spot and Phyllosticta leaf spot were also present but at lower levels. In 1978 bacterial blight and brown spot were widespread by early August. Brown spot usually infected the lower leaves and bacterial blight the upper ones. By early September, however, only brown spot was severe.

Table 1. — Severity of Soybean Foliar Diseases on Selected Cultivars at R5 and R6 Growth Stages[a]

Maturity group, cultivar	Brown spot 1977	Brown spot 1978	Bacterial blight 1977	Bacterial blight 1978	Downy mildew 1977	Downy mildew 1978
			percent[b]			
I — Hodgson	21	..	20	..	8	..
II — Amsoy	39	20	16	6	5	1
Amsoy 71	40	21	19	6	4	1
Beeson	..	21	..	5	..	2
Corsoy	24	27	19	5	6	3
Wells	39	26	27	4	13	3
III — Elf	55	22	54	6	5	6
L22	..	22	..	2	..	7
Williams	52	22	46	3	3	6
Woodworth	41	20	38	3	14	5
IV — Clark	50	21	54	5	16	6
Clark 63	46	21	40	5	19	7
Cutler	53	21	38	5	9	4
Franklin	47	20	38	5	13	7
Kent	47	21	48	6	8	4
Union	49	21	46	5	0	0
V — Essex	..	18	..	9	..	2
FLSD .10	9.2	2.5	23.4	1.4	NS	1.7
.05	11.1	3.1	34.4	1.7	NS	2.1

[a] Beans developing in pods at one of the uppermost nodes.
[b] Percentage of leaf area diseased; mean of 3 replicates from locations where severity was greater than 1 percent.

Table 2. — Severity of Soybean Foliar Diseases in Illinois During Early Aug. and Sept., 1977 and 1978

	Brown spot Aug.	Brown spot Sept.	Bacterial blight Aug.	Bacterial blight Sept.	Downy mildew Aug.	Downy mildew Sept.
			percent[a]			
1977—Northern						
DeKalb	T[b]	23	12	49	T	0
Central						
Urbana	12	67	T	0	3	10
Southern						
Brownstown	64	65	0	0	7	7
1978—Northern						
DeKalb	35	47	16	4	T	3
Saunemin	38	44	8	2	T	3
Manlius	20	31	9	2	5	4
Central						
Urbana	22	75	1	5	1	0
Hartsburg	25	51	2	1	T	6
Macomb	35	28	8	2	0	3
Southern						
Brownstown	1	47	0	T	T	3
Belleville	19	40	0	T	34	10
Carbondale	7	27	T	T	2	2
Eldorado	1	13	T	T	2	2

[a] Percentage of leaf area diseased; mean of 3 replicates for all cultivars.
[b] T = trace amounts of disease (less than 1 percent severity).

Bacterial pustule, which commonly occurs in southern Illinois, was observed last year at all three northern locations, reaching 7 percent at Manlius. Cultivars typically grown in the north are susceptible to the disease, while some late-maturing, southern varieties such as Clark 63 are resistant.

In central Illinois the most prevalent foliar disease was brown spot. At Urbana it reached 67 percent in early September, 1977, and 75 percent in 1978. Hartsburg had 51 percent and Macomb 28 percent during the second season. In the most severe cases, plants had lost three-fourths of their leaves by late August.

In southern Illinois foliar diseases reached their maximum severity early in the 1977 season. By the first week in August brown spot was 64 percent, downy mildew 7 percent, and Phyllosticta leaf spot 19 percent. In contrast, brown spot developed much more slowly in 1978. By early August it was only 1 to 19 percent, but within a month had increased to 13 to 47 percent. This late development was probably due to the extremely wet spring, followed by an extended dry period after late plantings.

These weather conditions apparently had little effect on downy mildew, which developed early in the 1978 season, especially at Belleville. Seeds from locations where downy mildew was prevalent were often covered with oospores.

Cultivar differences

In general, late cultivars were more severely infected at the R5 and R6 growth stages than were the early varieties. (At these stages beans are developing in pods at one of the uppermost nodes.) A longer period for disease development in the late cultivars, provided conditions are favorable, may account for the differences between early and late cultivars. When brown spot was severe in 1977, for example, the late cultivars were more severely infected than the early ones. With milder infections a year later, however, brown spot was about the same in all cultivars.

Cultivars responded in much the same way to downy mildew. Last year only Union from group IV and Essex from group V were less severely infected than the other late cultivars. Union, released as downy mildew resistant in 1977, may actually be immune; no downy mildew was observed on it either year at any location.

Program expansion

With the information gathered on foliar diseases thus far, the soybean monitoring program is off to a promising start. As it expands, we will add information about other soybean diseases, the relation between weather and epidemics, and the influence of cultivars on pathogen populations. The monitor plots will also serve as a source of pathogen cultures, which are used to screen for disease resistance and to study pathogen variation.

Aided by a better understanding of disease patterns, plant pathologists will be able to develop disease probability curves. With these models we can then forecast high-risk conditions that may cause economically damaging yield losses.

Foliar Fertilization of Wheat, Oats, and Soybeans

L. F. WELCH, C. M. BROWN, and R. R. JOHNSON

IMPROVING THE YIELDS of agronomic crops is a perennial goal of the Illinois Agricultural Experiment Station. Nutrients are essential to plant growth, and unless the supply is adequate, high yields cannot be obtained.

Three of these nutrients — carbon, hydrogen, and oxygen — are absorbed by plants as carbon dioxide and water. Because few soils contain enough of the other required elements, fertilizer is added as a supplement. It is customarily applied to the soil rather than to the leaves for convenience of application and to prevent plant damage, which occurs at the rates often necessary to overcome soil deficiencies.

During grain development, some of the nutrients stored in the leaves and other vegetative parts translocate to the grain. If the vegetative tissue lacks enough nutrients, the amount available for transfer when the grain begins to form will be inadequate. In such situations, nutrient deficiencies occur, photosynthesis slows, and grain yields decline.

Some researchers have suggested that nutrient levels in the plant may sometimes be too low for maximum grain production even when the soil supply is adequate. If this is true, one might expect that foliar application of nutrients, with or without soil application, will lead to yield increases. The purpose of our research was to test this hypothesis on wheat, oats, and soybeans.

Method of treatment

The nitrogen applied to the foliage was a chemical grade urea containing 0.29 percent biuret, a crystalline compound of urea. For soil application ammonium nitrate was used. Phosphorus, potassium, and sulfur were applied to the foliage as potassium polyphosphate and potassium sulfate. With foliar treatment we used a surfactant, which is a liquid agent that aids in dispersing the nutrients. The spray volume was 40 to 60 gallons per acre at a pressure of 30 pounds per square inch. The few exceptions to these methods will be noted later.

Winter wheat and spring oats

In the first wheat study, nitrogen was applied to the soil at 0, 20, 40, and 60 pounds per acre and to the leaves at the same rates in one, two, or three sprayings. Because the soil was initially fairly high in nitrogen, both treatments produced only modest yield increases (Table 1).

Table 1. — Yields of Abe Winter Wheat With Soil and Foliar Applications of Nitrogen

Ammonium nitrate applied to soil April 25, *lb N/A*	Urea applied to leaves, *lb N/A*: April 25 (late tillering)	May 3 (early boot)	May 11 (late boot)	Total foliar	Yield, *bu/A*
0	0	0	0	0	65
0	20	0	0	20	67
0	20	20	0	40	70
0	20	20	20	60	71
20	0	0	0	0	73
20	20	0	0	20	73
20	20	20	0	40	71
20	20	20	20	60	73
40	0	0	0	0	77
40	20	0	0	20	72
40	20	20	0	40	72
40	20	20	20	60	72
60	0	0	0	0	70
60	20	0	0	20	70
60	20	20	0	40	72
60	20	20	20	60	68

Table 2. — Oat and Wheat Yields With Foliar Fertilization

Treatment number	N	P_2O_5	K_2O	S	Oat yield: Otee	Noble	Wheat yield, Abe
	lb/A[a]				*bu/A*		
1	0	0	0	0	104	89	52
2	10	0	0	0	99	90	55
3	20	0	0	0	95	84	52
4	0	5	8	1	98	92	55
5	10	5	8	1	97	80	54
6	20	5	8	1	93	81	53

[a] Per spraying. The oats were sprayed on May 24 (late tillering) and June 2 (early boot), and the wheat on May 11 (mid boot) and May 21 (heading).

L. F. Welch is professor of soil fertility; C. M. Brown, professor of plant breeding; and R. R. Johnson, associate professor of crop production.

Table 3. — Yields of Corsoy and Amsoy Soybeans With Various Foliar Fertilizer Treatments

Treatment per spraying				Corsoy		Amsoy	
N	P_2O_5	K_2O	S	Two appl.	Four appl.	Two appl.	Four appl.
lb/A				bu/A[a]			
0	0	0	0	53	61	50	56
20	0	0	0	54	54	48	53
0	5	8	1	55	58	51	56
10	5	8	1	54	56	50	58
20	5	8	1	57	55	46	52
30	7.5	12	1.5	51	52	47	46

[a] The soil areas were not the same for the experiments with the two sprayings and those with four. The difference in areas accounts for yield differences with no fertilizer applied. Spraying dates for the two sprayings were July 26 (Amsoy at R4 stage and Corsoy at R5) and August 16; and for the four sprayings, July 26 and August 2, 16, and 31.

Table 4. — Yields of Williams and Corsoy Soybeans With Foliar Fertilization at Two Row Widths

Treatment per spraying[a]				Williams		Corsoy	
N	P_2O_5	K_2O	S	30″ width	20″ width	30″ width	20″ width
lb/A				bu/A			
0	0	0	0	52	56	49	54
20	0	0	0	48	52	50	55
0	5	8	1	51	56	46	55
10	5	8	1	48	57	46	57
20	5	8	1	50	51	46	56
Folian:							
12	6	6	0.5	50	53	48	58

[a] All treatments except Folian were applied three times: August 1 (Williams at R4 stage and Corsoy at R5), 12, and 18. Folian, a product of Allied Chemical, was applied only on August 1.

When no nitrogen was applied to the soil, foliar applications increased wheat yields up to 6 bushels per acre. The foliar-applied nitrogen was not necessarily absorbed through the leaves, however. Some of it may have fallen to the soil during application or may have been washed from the plants by rain and absorbed through the roots.

In contrast, foliar applications did not affect yields when nitrogen — even as little as 20 pounds — was applied to the soil. These results suggest that foliar application of nitrogen will improve yields only if the soil supply is inadequate.

In later studies of both wheat and oats, foliar applications included phosphorus, potassium, and sulfur, as well as nitrogen (Table 2). Wheat and oat yields did not increase significantly with any treatment. In fact, with certain foliar applications two varieties of oats, Otee and Noble, yielded less. The second spraying of the two 20-pound treatments caused some slight leaf damage, although it did not seem severe enough to be the sole reason for the yield reduction.

Soybeans

Corsoy and Amsoy soybean varieties were sprayed either two or four times with various fertilizer solutions (Table 3). Yields were not significantly increased by any treatment and were actually reduced at the highest fertilizer rate when applied four times.

The yield reduction may have been partly due to leaf damage from the 20- and 30-pound nitrogen applications. With the treatment that included only phosphorus, potassium, and sulfur, no damage was apparent. The 30 pounds of nitrogen damaged about 20 percent of the leaf area in the upper canopy. At the 10-pound rate, damage was about 4 percent.

Later studies included some of the treatments from the earlier experiments plus Folian, a commercially available product, the varieties Williams and Corsoy, and two row spacings (Table 4). The only noticeable difference was that the 20-inch row spacings produced higher yields than the 30-inch widths.

In a study with Harosoy soybeans, Folian was sprayed either once or twice at two rates; nitrogen was also applied to the soil (Table 5). None of these treatments produced yields higher than those obtained without fertilization. Nor did any of the treatments affect maturity date, plant height, lodging, or grain moisture at harvest. Some leaf damage occurred the second day after Folian was sprayed the first time, but not after the second spraying.

Some farmers double-crop soybeans after the wheat harvest, thereby obtaining two yields from the same land in one year. Because the beans are planted at a late date, we thought they might possibly benefit from foliar fertilization. To test this idea, we used urea, potassium, phosphorus,

Table 5. — Yields of Harosoy Soybeans With Soil-Applied Nitrogen and Two Rates of Folian

Fertilizer treatment per acre	Yield, bu/A	Protein, pct.
None	55	37.3
Urea, 75 lb/A to soil on July 30	53	38.5
Folian to leaves:[a]		
10 gal. on July 25[b]	49	38.4
10 gal. on July 25 and on Aug. 9	54	38.0
20 gal. on July 25	53	38.4
20 gal. on July 25 and on Aug. 9	50	38.2
LSD (0.05)	NS	1.2

[a] Ten gallons of Folian, a product of Allied Chemical, contain 12, 6, 6, and 0.5 pounds of N, P_2O_5, K_2O, and S, respectively.
[b] R4 stage of growth.

and sulfur at a rate schedule similar to the one in Table 4. In addition, we ran tests with foliar applications of ammonium nitrate at 20 pounds per acre with and without the other nutrients.

Yields were not affected by any of the urea treatments, but were reduced about 10 bushels per acre (from 24 to 14) by the ammonium nitrate, which caused severe leaf damage. These results support what is generally known: that ammonium nitrate applied to leaves is more damaging than urea.

The results of our foliar application tests do not leave much room for optimism. The yields from wheat, oats, and soybeans did not increase with foliar treatment when adequate levels of nutrients were maintained in the soil.

Historical Design In Your Home Town

HAROLD H. ALEXANDER

PERHAPS BECAUSE of the Bicentennial three years ago and literature and television programs such as "Roots," Americans today are more curious than the last generation about their cultural heritage. A marked growth in travel to other lands has also aroused interest in the foreign and unusual. But did you know that you can often see the foreign and unusual, and the historical as well, in your own home town?

Look around! In most midwest towns you can discover building and furniture forms of another era or country. The local church probably resembles in decorative detail, if not in actual form, a Gothic church built 400 years ago. And, provided it has not recently been remodeled, your local bank may have columns that could have come from a Roman temple.

The county courthouse, the high school, the local jail, or even your home or your neighbor's may have a clear design heritage from structures of the past. Inside, many of the basic furniture forms, especially chairs, have changed little since they evolved more than 5,000 years ago. Examine the profile of the moldings on your furniture and woodwork; that simple or compound curve is probably like one used by the Greeks before 400 B.C.

Ancient Egypt seems less remote when we look at a local tomb resembling the entrance to an Egyptian temple, or a tombstone modeled after a towering obelisk. The architectural

Your town probably has a house similar to the one above. Its windows are a simplified rendering of an arch in the Temple of Hadrian (117 to 135 A.D.), pictured on the cover. The motif is repeated in Andrea Palladio's 1549 basilica (*below*) at Vicenza, Italy, and in the beautiful west window of the English Building (*right*) at the University of Illinois.

Harold H. Alexander is associate professor of interior design and housing.

influence of Greece and Rome is everywhere. Careful observation will often reveal classical motifs and details on doorknobs, plates, mirror frames, or even on the plastic placemat under the dog's dish.

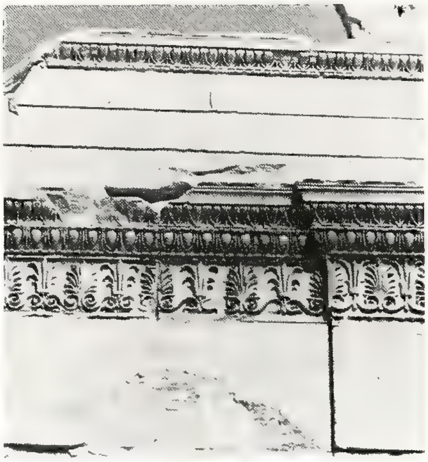
The small wooden blocks repeated like teeth around a porch or gable are dentils such as those adorning the Erechtheum (421 to 405 B.C.) on the Acropolis at Athens. Columns, capitals, pediments, acanthus leaves, frets, volutes, egg-and-dart and bead-and-reel moldings, large and small, are easy to find.

Above the trees in towns and cities of Illinois and other midwestern states, church steeples pierce the sky, creating landscapes not unlike the cathedral towns of medieval Europe. Upon closer examination the observer will frequently find pointed arched windows and doorways, sculptured and carved decorations, stained glass windows, many vertical forms, and maybe a gargoyle or two — all distinctly related to the Gothic period.

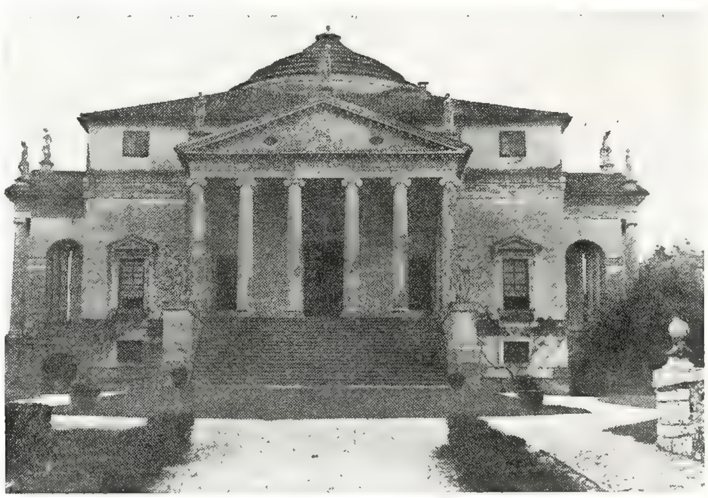
With the beginning of the Italian Renaissance in about 1400, the details and forms of previous periods were adopted and modified. Through the centuries these forms have been incorporated in the exterior and interior design of buildings and in the furniture still being used today.

For a number of years I have photographed examples of architecture and furniture in Europe and Illinois. The affinity of design is often striking, occasionally elusive, and sometimes strange, but discovering a new connection is always exciting. These examples have stimulated many people — students in history of architecture and furniture design classes, and laymen attending community presentations — to look anew at their surroundings and, in turn, to become more interested in their environment.

Some of the photographs presented here were taken in or near Champaign-Urbana, Illinois. But the subjects are not unique to this area; similar examples of the merging of old and new can be found throughout the United States.



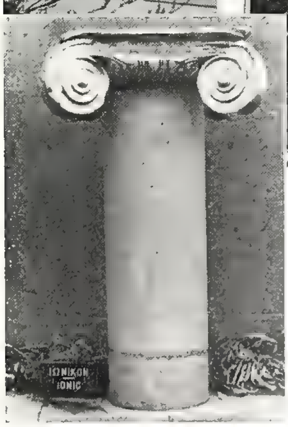
Affinity of design is not always easy to detect, but the discovery of similarities is a rewarding experience. The crudely carved design on the apron of this little table has an elusive connection with the exceptionally fine egg-and-dart moldings of the Erechtheum, built on the Acropolis at Athens more than 2000 years ago.



The influence of Rome's Pantheon (120 to 124 A.D.) is seen in the Villa Rotunda (*above*), built 1550 to 1553 at Vicenza, Italy. The Villa obviously inspired the design of the venerable Auditorium (*below*) on the University of Illinois campus.

The Tudor style was much admired in the United States fifty years ago. The "cottage" pictured below has a simulated thatched roof, several exterior materials, and the half-timber look — all designed to capture the spirit of the most famous English cottage, that of Anne Hathaway near Stratford-on-Avon (***right***).

The Urbana Free Library (***below***), formerly the Samuel T. Busey Library, has a central entrance that is quite like the Arch of Titus (82 A.D.) in Rome. Note that the dedication on both is on the topmost portion, the attic story.



The Ionic capital (***c.***400 B.C.) is the prototype of the rather primitive capital on this early 20th century porch. The corner capital is especially interesting because it harks back to the ram's head and horn, the origin of the identifying volute of the Ionic capital.

Enzyme-Modified Proteins:

A New Generation of Functional Food Ingredients

W. DAVID DEESLIE and MUNIR CHERYAN

THE FOOD INDUSTRY is constantly searching for new and better food ingredients to use in making palatable, safe, and nutritious products. Particular attention is being paid to developing modified proteins for foods such as meat extenders, sauces, gravies, and whipped toppings. After the nutritional value and safety of protein ingredients are established, the functional properties responsible for making a food palatable and appetizing become paramount.

During the past decade utilization of plant proteins, especially from soybeans, has increased tremendously, primarily for nutritional and economic reasons. In many cases, however, the texture or flavor needs to be altered for certain uses. Functionally modified proteins, collectively known as hydrolyzed proteins or hydrolyzates, have been introduced quite recently to meet this need.

The usual raw materials for manufacturing hydrolyzates are meat, fish, blood, dairy products, grains, alfalfa and other leaves, and oilseeds such as soybeans, peanuts, and cottonseed. Either chemical (acid or alkali) or enzymatic methods can be used to produce hydrolyzates. In acid hydrolysis, strong acids at high temperatures break the chemical bonds of the protein. Uncomplicated but relatively harsh, this treatment can result in some loss of essential amino acids and in undesirable side-reactions with nonprotein components of the reaction mixture. Alkaline hydrolysis also requires fairly extreme conditions for producing the reaction. Consequently there is always the danger that lysinoalanine, a potentially toxic by-product, may form. In addition, the large amount of residual acid or alkali in the hydrolyzate limits its use in most food products.

W. David Deeslie is a graduate research assistant and Munir Cheryan, assistant professor in the Department of Food Science. Their research is supported in part by the Illinois Soybean Program Operating Board.

Enzyme hydrolysis

Enzyme hydrolysis is an attractive alternative to chemical treatment because the process is mild. Moreover, the inherent specificity of various proteolytic enzymes should enable us to control the nature and extent of hydrolysis and thus the functional properties of the product.

Two major problems associated with this method have so far limited its general use. First, the cost of enzymes in conventional, batch-type hydrolytic systems can be prohibitive. The protein source and the enzyme are typically mixed in suspension at the optimum temperature and pH for a few hours. When the desired degree of hydrolysis is obtained, the enzyme is inactivated either by changing the pH, increasing the temperature, or both. Hence the enzyme can be used only once. The heat treatment also adds to the cost of this method.

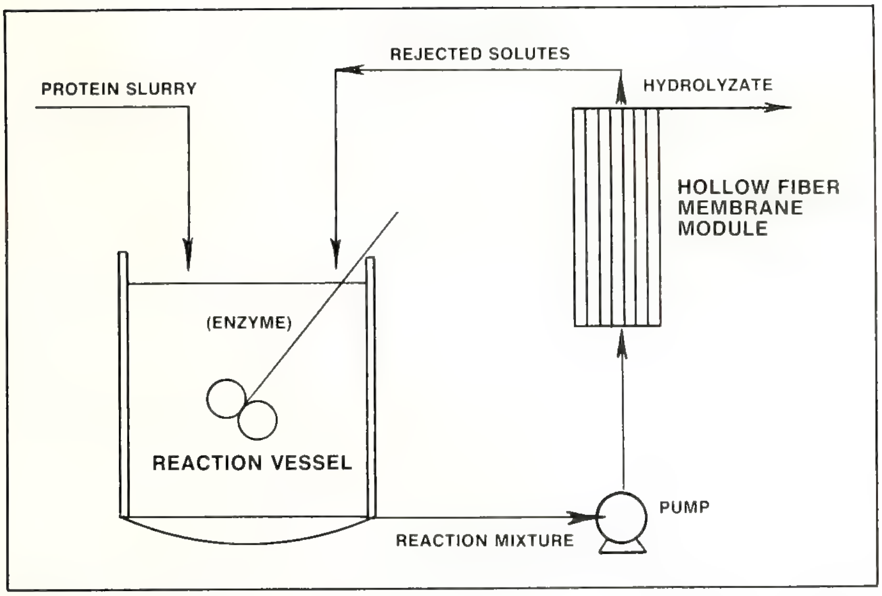
Second, the extent of the reaction must be carefully controlled. The few studies published to date indicate that if hydrolysis goes on too long or is uncontrolled, off-flavors or bitterness may develop.

The bitterness, which arises from the production of small peptides, seems to be especially pronounced if peptides with a molecular weight of less than 6,000 are produced. However, our research indicates that this condition depends to some extent on the protein and on the specificity of the enzyme. Milk and soy proteins in particular often develop an intensely bitter flavor when hydrolyzed.

Many of the unwanted effects can be overcome by using enzyme immobilization and ultrafiltration, two technologies that are developing rapidly. In the first of these processes, the enzyme is immobilized, either by chemical procedures or physical adsorption, when attached to a solid support such as silica, alumina, or iron oxide. The reaction mixture is then allowed to flow through a column containing the immobilized enzyme. The extent of hydrolysis is controlled essentially by the flow rate or length of time in the reactor. A major drawback is that immobilization causes a large drop in enzyme activity. The procedure is also fairly expensive.

Ultrafiltration, an alternative to immobilization, is being investigated at present in the Department of Food Science under a grant from the Illinois Soybean Program Operating Board. This process uses ultrafiltration membranes, which are essentially filters with very fine pores that retain macromolecules but permit passage of small molecules. The basic concept is illustrated in Figure 1.

Enzyme-membrane reactors have been demonstrated by other researchers for hydrolysis of starch, and alfalfa, cottonseed, and fish proteins. In these early studies, however, several problems were encountered, for example, poor engineering design of the units and a fairly rapid drop in reactor output from the accumulation of unhydrolyzed material on the membrane. Our approach was to de-



Continuous enzyme-membrane reactor. Protein slurry is pumped into the reaction vessel, where an enzyme initiates hydrolysis. The reaction mixture, consisting of hydrolyzed and unreacted protein and enzyme, is pumped under pressure from the vessel across a hollow fiber membrane, which filters out the hydrolyzate. Enzyme and partly hydrolyzed protein return to the vessel for further reaction. (Fig. 1)

sign and perfect the ultrafiltration unit and the reaction vessel separately, then to merge the two parts of the system, and finally to optimize the entire system.

In the operation we developed, a continuous stirred-tank reactor is connected to a hollow fiber ultrafiltration unit in a closed-loop system. Enzyme and protein are allowed to react in the vessel until the desired degree of hydrolysis is obtained. At this point the reaction mixture — consisting of enzyme, unreacted and partly hydrolyzed protein, and hydrolyzate — is pumped under pressure past the ultrafiltration membrane.

The hydrolyzate molecules, being smaller than the pores of the membrane, pass through and are removed as product. The enzyme and those partly or unhydrolyzed protein molecules too large to go through the membrane are returned to the vessel for further reaction. By careful selection of operating parameters and membrane characteristics, a continuous steady-state operation can be achieved. Since the enzyme is still in its soluble form, diffusional resistances are much less and enzyme activity is much higher than in immobilized systems.

Advantages of membrane reactor

This type of operation has several advantages. The enzyme stays within the system and hence can be recycled and used a number of times, thus vastly improving the productivity of the system and the efficiency of enzyme utilization. Unlike the batch process, the continuous process can operate for an extended time and is relatively easy to maintain.

Most important, in ultrafiltration fairly close control of molecular size is possible. With the hollow fiber unit having a molecular weight cut-off of 10,000, the product averaged 92 percent protein ($N \times 6.25$) and 7 percent ash, compared with 93 percent protein and 4.5 percent ash for the unhydrolyzed protein isolate used as feed in the reactor. The product's molecular size, determined by gel permeation chromatography, indicated that there were three major peptide fractions in the product. The largest one corresponded to 2,500 molecular weight and the others to 900 and 180.

The molecular weight or size of the product appears to be controlled essentially by the membrane's pore size, while the percent hydrolysis or yields are controlled by the amount and activity of the enzyme, reaction volume, flow rate, and substrate concentration in the feed. (Yield is defined as product output rate divided by feed input rate.) With our enzyme-membrane system we have obtained yields in excess of 90 percent, compared with 65 percent in conventional batch hydrolysis systems.

Functional properties

Solubility is the most important functional property of a protein, which generally has to be in solution to exert its other desirable properties. Many commercial protein isolates are not too suitable for food product formulation, primarily because of poor solubility. The hydrolyzate, on the other hand, is completely dispersible over the entire pH range, and so can be used to fortify acidic foods or beverages. Other properties of interest include emulsification, whipping, foaming, and water binding.

Researchers in the field commonly believe that functional properties are governed to a large extent by molecular size. The ultrafiltration method of producing hydrolyzates now affords the opportunity to study such effects. The use of membranes with different pore sizes should produce hydrolyzates of correspondingly different molecular sizes, each of which probably has a unique set of functional properties.

Protein hydrolyzates are important in formulating special diets to treat people who are allergic to proteins or are unable to properly digest and absorb protein from a normal diet. In such cases predigested, protein-based products are relied upon, but they are expensive when produced by conventional means.

Whether made by a chemical or an enzymatic process, protein hydrolyzates are generally recognized as safe. However, people who consume large amounts of acid-hydrolyzed protein should do so with caution because of the excess salt levels in these products. In the future, ultrafiltration reactors may prove to be a practical method for producing safe yet relatively inexpensive protein ingredients.

Dairying in Illinois:
Past, Present, and Future

SHELDON WILLIAMS

DAIRYING IN ILLINOIS has been steadily declining over the years. Major changes have taken place in both milk production and marketing, and further changes appear likely in the 1980's.

Production

During the past half century, milk production has decreased substantially. In 1925 Illinois ranked fifth among the states, with 4.3 billion pounds of milk or 4.8 percent of the U.S. total. By 1977 the state was twelfth, producing 2.5 billion pounds or 2 percent of the national output. This reduction reflected a striking decline in the number of dairy cows, and occurred even though average production per cow is now about two and a half times that of 50 years ago.

Reduced milk production in Illinois has been associated with increased specialization and commercialization of farming. Crop rotations and livestock no longer play their once important role in soil fertility maintenance, and few farmers now keep dairy cows to supply fresh milk for home use. Moreover, mechanical and technological advances have greatly increased the quantity of corn and soybeans a farm family can produce, thus facilitating specialization in row-crop production.

With these developments, dairying is changing from a supplementary enterprise on many farms to a major enterprise on a relatively few farms that derive their income largely from milk production. Consequently, the future importance of dairying will depend upon how profitable it is in relation to other farm enterprises with which it competes for labor, land, and other production resources.

During the past two decades milk production has generally been somewhat less profitable than grain and hog production in northern Illinois, though more competitive in the southern part of the state, according to records of the Illinois Farm Business Farm Management Association.

These changes point to a continuing decline in milk production during the 1980's (Table 1). Projections based on trends for 1967 through 1977 indicate that, although production per cow will continue to increase, the state total by 1985 will probably be between 1.6 and 2 billion pounds, or 1.3 to 1.6 percent of the U.S. production. By 1990 it could be in the range of 1.3 to 1.75 billion pounds, amounting to 1 to 1.3 percent of the national output.

Emerging dairy areas

With increasing specialization and commercialization, dairying has become concentrated within a few areas of the state and will continue to be centered there (see map). The northwest crop reporting district, which in 1977 produced 37 percent of Illinois's milk, is expected to maintain that share, but increasing urbanization in the northeast district will cause its share to decline.

Downstate, percentages in the southwest and east southeast districts will rise. By 1990 slightly more than a fourth of the state's milk will be produced in Stephenson and Jo Daviess Counties, and about another fourth in Clinton, Washington, Effingham, and McHenry Counties.

Changes in milk production

As dairying has become more specialized, average herd size has increased markedly. For example, between 1962 and 1975 the percentage of all milk cows in herds of 50 or more increased from 13 to 43 in the northwest crop reporting district and from 4 to 48 in the southwest. Herd size in Illinois is, and probably will continue to be, below that in some states in the Northeast, South, and West. Nevertheless, if the upward trend continues at recent rates, by 1990 some 75 to 80 percent of Illinois's milk cows will be in herds of 50 or more, and 15 to 20 percent in herds of 100 or more.

The increase in herd size has been accompanied by rising output per cow, and this trend also will continue. Average annual production per cow increased from not quite 7,000 pounds in the late 1950's to approximately 10,600 pounds in 1977. Projections based on the trend during the past decade suggest that production per cow will be 12,000 to 12,500 pounds by 1990.

Although substantial, this increase has not matched that in the United States. As a result, in Illinois the average production per cow, which was 5 to 10 percent above the na-

Table 1. — Changes in Illinois Dairying, Past and Projections

	Number of milk cows (1,000)	Av. annual production per cow (lb)	Total milk production: Quantity (million lb)	Total milk production: Pct. of U.S.
1955-59	708	6,856	4,837	3.9
1970-74	278	9,867	2,739	2.3
1977	234	10,598	2,480	2.0
Projections:				
1985	140-170	11,500-12,000	1,600-2,000	1.3-1.6
1990	110-140	12,000-12,500	1,300-1,750	1.0-1.3

Historical data are from USDA estimates of milk production.

Sheldon Williams is professor of agricultural economics. A more detailed report on dairying appears in AERR 172, "The Dairy Industry," which is part of *Agriculture in Illinois: Alternative Futures for the 1980's.*

tional average during most of the 1960's, had dropped to 5 percent below by 1977, and now seems likely to stay lower throughout the 1980's.

Another noteworthy development is the trend to drylot feeding. The average number of pasture-days per animal unit on dairy farms in the Illinois Farm Business Farm Management Association decreased from 142 in 1959 to 28 in 1976. As dairy farmers have decreased their use of pasture, they have reduced the acreage used to produce grass-legume forage while feeding more soilage and silage crops and more grain. In general, the farmers who still pasture their cows have smaller than average herds and below average milk production per cow.

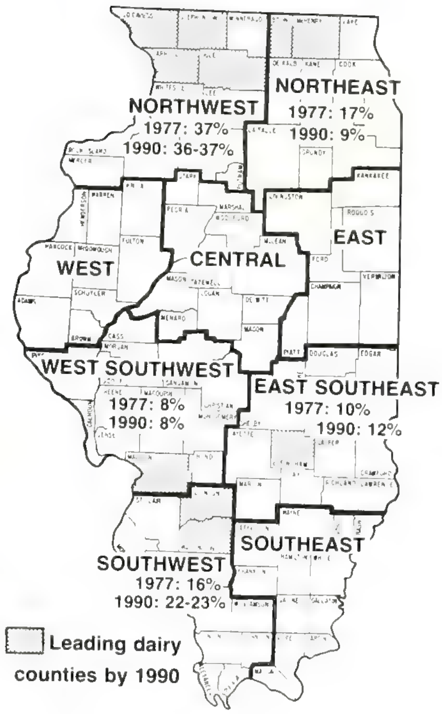
Adapting production to conditions

What adjustments should milk producers be making in light of past and probable future developments? One alternative when dairying is unprofitable is for the producer to go out of business; many have been doing so in recent years. But producers for whom dairying can be a competitive enterprise have other choices, particularly if they are in an area suited to production.

The alternatives involve taking steps to improve efficiency primarily by increasing the production per cow and enlarging the herd. Studies have repeatedly shown that high production per cow reduces the cost of production. Moreover, analyses of Illinois Farm Business Farm Management Association dairy farm records for the 5 years from 1973 to 1977 indicate that the average cost of production was 5 percent lower in herds of 80 or more than in herds of 40 to 80 cows. These findings strongly suggest that dairy farmers with herds well above average both in per-cow production and in herd size will be in the best position to compete in the future.

Marketing

Much of the milk from Illinois meets the fluid-grade standards for packaged fluid milk and cream. The only major exception is in north-



western Illinois, where perhaps 25 to 30 percent of the milk is still sold directly to dairy manufacturing plants. Chicago and St. Louis are the dominant markets for fluid milk, but there are processing plants in most parts of the state.

While Illinois has produced a variety of dairy products in the past, its proportion of the national output of most manufactured products has declined sharply during the past 10 to 20 years. Illinois's share is largest for Swiss cheese — nearly one-fourth in recent years. The state now manufactures about 5 percent of the nation's ice cream and cottage cheese, and 3 percent of the Italian cheese, but less than 1 percent each of butter and American cheese. If trends of the past decade continue, Illinois will maintain its share of ice cream production, but will produce decreasing proportions of other manufactured dairy products.

Fluid milk processing changes

The number of fluid milk processing and packaging plants in Illinois declined from 364 in 1950 to 48 in 1976. Accompanying this decline was a pronounced increase in plant size. In 1950 plants typically were small: 94 percent processed less than 5,000 gallons per day and 46 percent less than 500 gallons. In 1976, by contrast, 71 percent processed 5,000 gallons or more per day and 34 percent processed 20,000 gallons or more.

Increased plant size was accompanied by important ownership changes. In recent years the role of food distributors in marketing milk has grown. As a result, the percentage of the state's fluid milk processed in plants operated by corporate or other food chains increased from 6 in 1964 to 26 in 1976.

During this same period the proportion of milk processed in plants of farmer cooperatives and of processors who marketed part or all of their milk through their own stores increased from 8 to 16 percent.

The increases in market shares of these vertically integrated processors were offset by declines in the percentage of milk processed by national and regional chain dairies from 52 percent in 1964 to 33 percent in 1976. The aggregate market share of single-unit, nonintegrated plants also declined, from 34 to 26 percent. However, while most small independent plants have been forced out of business, the larger single-unit, nonintegrated firms have more than maintained their market shares in recent years.

Trends in fluid milk sales

Because production in Illinois is primarily for the fluid market, the outlook for dairying in the state will be affected by the trend in consumption of packaged milk products. In recent years that trend has been generally downward. The quantity of milk consumed nationally as fluid milk and cream decreased from an average of 322 pounds per person in 1960 to 243 pounds in 1977, a drop of 25 percent. However, the slackening rate of decline in the mid-1970's suggests that it may not be as sharp in the future.

As consumers have switched from whole to low fat or skim milk and reduced their use of cream, the

average fat content of fluid milk products sold in city markets has dropped substantially. In Chicago and St. Louis the average is now 0.7 to 0.8 percent below that in milk received from producers. If this spread increases, excess milk fat could become burdensome to firms that process fluid milk.

Strengthening markets

The dairy industry obviously needs to counter the declining consumption of fluid milk, perhaps by exploring the following suggestions:

— More emphasis on product design and development. Greater attention should be given to tailoring dairy products to consumer wants. Marketing fruit-flavored and aseptically packaged fluid milk products are two possibilities.

— Developing outlets competitive with food chains, where fluid milk products are only a few among thousands of items. In some areas processor-owned dairy stores feature milk at relatively low prices, operate profitably, and presumably strengthen the demand for milk.

— More effective advertising and merchandising. Improvement is needed to counteract intensive promotion of milk substitutes, to inform consumers of modified dairy products that may appeal to them, and to publicize new distribution methods.

Orotate in Bovine Milk

ROBERTA P. DURSCHLAG, BARRY W. JESSE, and JAMES L. ROBINSON

Orotate is a natural metabolite found in cows' milk. Nonruminant milk contains virtually no orotate (orotic acid), but humans invariably ingest some in a diet that includes cows' milk and milk products. Research in our laboratory has centered on measuring orotate levels in the milk of dairy cows and determining the metabolic effects of orotate on various mammalian species.

Orotate in cow's milk

Orotate concentrations in the morning milk of all 250 lactating cows in the University of Illinois dairy herd are shown in Figure 1. The average was 81.1 micrograms per milliliter (μg/ml), which is virtually the same as the 80 μg/ml found in market milk. At this concentration orotate accounts for about 0.1 percent of the total nonfat milk solids. The variation in orotate concentrations was surprisingly large between animals. Major milk components such as protein and fat usually do not show such variability, although concentrations of lactoferrin, another minor milk component, also vary widely.

Roberta P. Durschlag is a research assistant; Barry W. Jesse, a former research assistant; and James L. Robinson, associate professor of biochemistry in the Department of Dairy Science.

Orotate in the milk of the three cows with the lowest levels never exceeded 40 μg/ml during a five-month period. By comparison, concentrations were exceptionally high for two cows: cow 2778 had 664 μg/ml and cow 3365, 346 μg/ml.

The herd survey revealed differences in orotate concentrations attributable to breed. Milk from Guernsey and Jersey cows contained less orotate than did milk from Holstein-Friesian, Ayrshire, and Brown Swiss. These differences will have to be verified with a larger sample of non-Holsteins, which constituted only 20 percent of the animals surveyed.

We also studied the effect that the stage of lactation has on orotate secretion in Holstein-Friesians. At the outset of lactation the concentrations were very low, first-drawn colostrum containing about 10 μg/ml (Fig. 2). In subsequent milkings the level rose until it reached 76 μg/ml by the tenth week. This level was maintained until week 38, when it started to decline. Milk production followed the expected pattern, peaking by the eighth week.

Because of her unusually high orotate secretion, cow 2778 was of particular interest and so was studied throughout an entire lactation. At all stages her milk contained levels four to ten times higher than those of the other cows in the herd. During the ensuing dry period, her lacteal secretions contained 35 μg/ml, compared with 5.7 in the others. Throughout the next lactation, her milk orotate was similarly elevated.

Our findings for cow 2778 suggest that these high concentrations are a persistent characteristic of this cow. None of her maternal or paternal half-sibs that we have been able to test produced milk with high orotate levels. In December, 1978, cow 2778 gave birth to a female calf, and we are eagerly awaiting her first lactation to see if she too will have high levels in her milk.

Metabolic effects of orotate

It has long been known that abnormal levels of fat accumulate in the livers of rats that have been fed orotate at 1 percent of the diet for 10 days. We determined both the minimal levels of dietary orotate and the number of feeding days necessary to induce a fatty liver. To estimate the potential hazard to human health, we examined the effects of orotate on six mammalian species.

Fed at 1 percent of the diet, orotate led to a fatty liver in rats by the seventh day; no fat was observed on the third day. (The rats were not

examined on days 4, 5, and 6.) However, the rats were receiving ten times the level normally found in pooled commercial milk, which contains only about 0.1 percent orotate in the nonfat solids. At this lower level no fat was observed by the tenth day, but some had accumulated by then when orotate was fed at 0.5 percent.

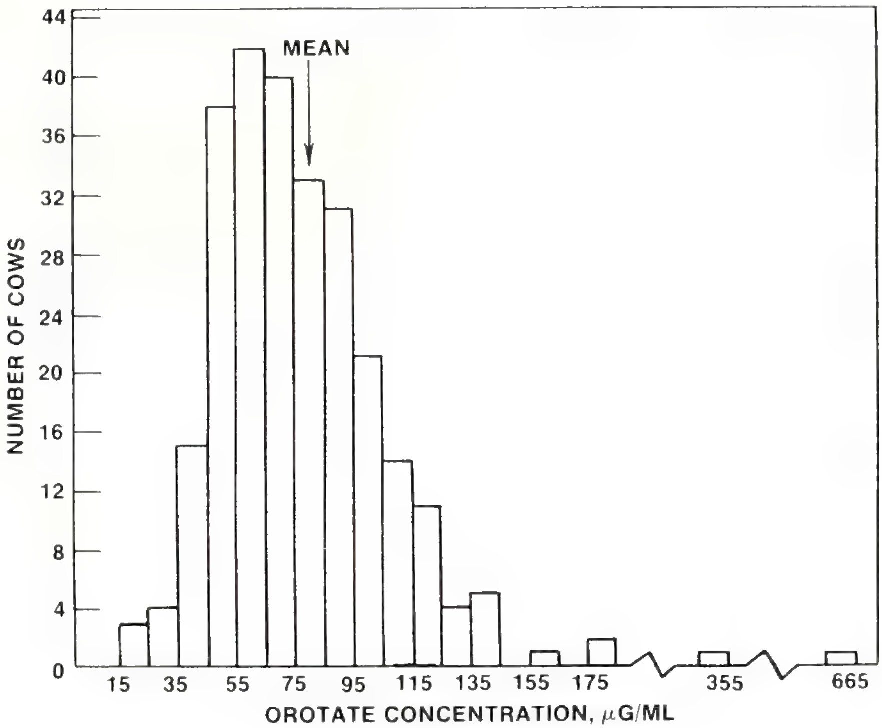
The effect of feeding orotate at 1 percent of the diet to various species is shown in Figure 3. Of the six species studied, only rats developed a fatty liver; mice, guinea pigs, hamsters, pigs, and monkeys did not seem to be significantly affected.

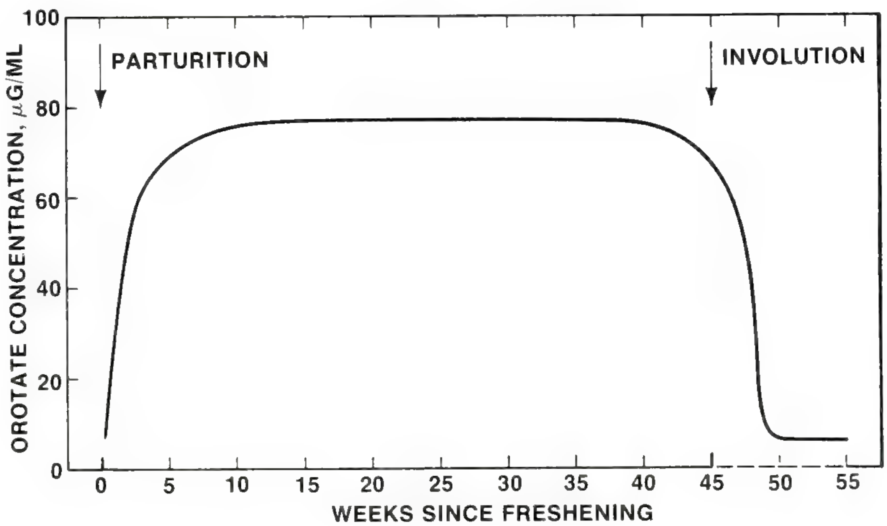
Additional studies comparing rats, which are susceptible, and mice, which are not, suggest possible reasons for the species specificity. After feeding, mice accumulated less orotate in their livers and excreted it in the urine much more rapidly than rats. Furthermore, after orotate ingestion, mice showed a less severe change in the levels of liver purines and pyrimidines (critical cellular metabolites), a response that may protect mice from developing fatty livers.

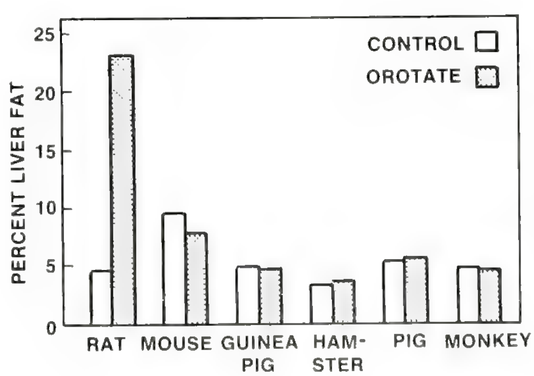
Effects on humans

Our findings indicate that orotate probably does not pose a health hazard to adult humans. Although our investigations were limited to six nonhuman species, the fact that only rats developed fatty livers argues against the possibility that humans will do so too. In the typical adult diet, orotate constitutes only 0.005 percent of the total solids, a value at which even rats show no liver changes.

Human infants on a basic diet of cows' milk receive about 0.1 percent orotate, which was too low to produce significant liver changes in any of the species we examined, including rats. Both rats and mice did show some changes in purine and pyrimidine levels when orotate was fed at 1 percent of the diet. It is reasonable to predict from our findings that infants will experience no serious effects from the low concentration of orotate found in cows' milk.







At top, distribution of milk orotate levels among 250 dairy cows. (Fig. 1)

Center, variation in milk orotate during lactation in 8 Holstein-Friesian cows. (Fig. 2)

Bottom, species specificity of fatty liver induced by orotate at 1 percent of the diet. (Fig. 3)

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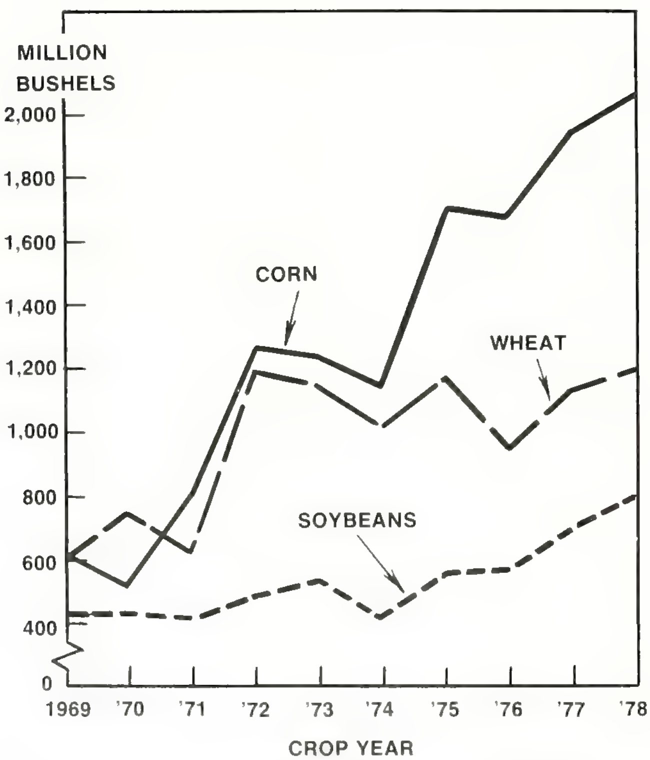
FARM BUSINESS TRENDS

During the past 10 years, U.S. grain and soybean exports have expanded quite rapidly (see graph). Current USDA estimates for the 1978 crop year place corn exports at 2.05 billion bushels, wheat at 1.2 billion bushels, and soybeans at 800 million bushels. If these estimates materialize, wheat and soybean exports will have almost doubled and corn exports more than tripled since 1969.

In 1978 corn exports will account for 30 percent of the total use of U.S. corn, compared with only 13 percent in 1969. Wheat exports have increased from 44 to 58 percent and soybeans from 35 to 42 percent of the total use during the same 10-year period. In addition, exports now account for about 27 percent of the annual soybean meal and 20 percent of the soybean oil used.



U.S. exports of corn, wheat, and soybeans. The 1978 figures are U.S. Department of Agriculture estimates issued May 11, 1979.

Year-to-year variations in wheat and corn exports reflect fluctuations in how much the United States and other exporting countries produce and how big or small the harvest is in importing countries. However, the demand for feed grains and soybean meal for livestock is clearly trending upward because of rising incomes and demand for meat around the world. Most countries prefer to import feed and produce their own livestock rather than import meat. The increased demand for whole soybeans and meal reflects greater livestock numbers and attempts by feeders to increase the protein content of livestock rations. The dip in exports during the 1974 crop year was due to weather-related crop reductions.

U.S. wheat tends to be exported in moderate amounts to many countries. During the current marketing year the major importers have been Japan, the People's Republic of China, the Soviet Union, the European Economic Community (EEC), Brazil, Pakistan, Korea, and Egypt. The major importers of U.S. corn are EEC, the Soviet Union, Japan, the People's Republic of China, and Korea. Soybeans are exported in large quantities to EEC and Japan, while the lion's share of meal goes to European countries. Pakistan, India, Iran, and the People's Republic of China are currently the largest customers for U.S. soybean oil.

The future for U.S. corn, wheat, and soybean exports is bright. The demand outside the United States for more livestock feed and feed of a higher protein content is likely to continue to rise, as will our share of the world market in corn and soybean exports. Wheat exports will depend largely on crop size and trade policies of other exporting countries. — *D. L. Good, assistant professor of agricultural economics*

Fall, 1979

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

IN THIS ISSUE

From soup to nuts — vending machines influence the snacking patterns of college students (page 3).

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE Volume 21, Number 4

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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(Cover picture by Paul Hixson)

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R. G. Cragle . . . . Director

Sheila R. Wiley . . . . Editor

THE PROFESSIONAL RESEARCHER

OVER THE YEARS our society has considered it a good investment to support a small percentage of its citizens in the pursuit of original inquiry. These people are professional researchers, and nearly three hundred of them work within the Illinois Agricultural Experiment Station, where they are on the faculties of the College of Agriculture and the College of Veterinary Medicine.

Recognized as public servants, these men and women have been entrusted with the freedom and responsibility to acquire new information and develop new concepts that might benefit society. As part of a great university, researchers are given the independence to seek truth, but they also have an obligation to serve the society that supports them.

Freedom of inquiry and accountability therefore go hand in hand. Taxpayers, legislators, and funding agencies have a right to expect the prudent use of monies and facilities. Most researchers willingly accept this responsibility as an underlying condition of their professional activities.

Dedication and scholarship have always been hallmarks of good research and service within the Illinois Agricultural Experiment Station. To maintain high standards we try to query ourselves frequently about the quality and relevance of our work. — *R. G. Cragle*

Vending Machines

MAHMOOD A. KHAN

Do they influence the snacking of college students?

TWO DECADES AGO soft drinks were about the only "food" sold through vending machines. Today entire meals, some of them quite nourishing, can be purchased from self-service dispensers. Most of the items typically sold this way, though, are high in calories and low in nutrients. Junk food is a popular phrase used to refer to snacks such as candy, chips, chewing gum, and cakes.

Mini-restaurants

Vending machines, like restaurants, cater to many tastes and needs. Hot-drink dispensers provide coffee, tea, and hot chocolate. Cold-drink dispensers are stocked with white milk, chocolate milk, fruit juices, and soft drinks. Food merchandisers supply sandwiches, hot dogs, hamburgers, fruit, and yogurt, along with the usual array of potato chips, desserts, crackers, and the like. And now can dispensers offer soups, chili, and stews.

Used wisely, vending machines can be a valuable supplement to food services in schools, factories, hospitals, offices, and recreational facilities. In many cases, unfortunately, neither suppliers nor consumers have taken advantage of vending machines as an outlet for nourishing foods.

Junk foods

According to the U.S. Department of Agriculture definition, foods of "minimum nutritional value" are those providing less than 5 percent of the recommended daily allowance of eight essential nutrients per 100 calories or in each serving. The nutrients specified are protein, vitamins A and C, niacin, riboflavin, thiamine, calcium, and iron.

Recently, in an effort to prevent competition between high-caloric snacks and the nutritious food supplied through federally subsidized school meal programs, USDA proposed limits to the sale of so-called junk foods in schools during certain hours of the day. Although restricting sales may be a good move, we need to know more than we do now about the snacking patterns of young people. How often do they snack? When are they most likely to use vending machines? What kinds of food do students buy, and do these foods replace regular meals?

Student survey

To answer these questions we surveyed 249 students enrolled at the University of Illinois during spring semester, 1979, using a 15-page questionnaire designed in consultation with the Survey Research Laboratory. The information requested included a recall of all meals and snacks eaten within the previous 24 hours, as well as time, place, quantity, brand name, method of preparation, and use of vending machines for each food and beverage consumed. Respondents were asked to indicate their age, sex, student classification, weight, height, and physical activities.

We also wanted to find out if nutrition education has any noticeable effect on eating habits. The questionnaires were therefore distributed to students in nutrition and non-nutrition programs; the courses were randomly selected. Group A consisted of 138 students enrolled in the social sciences and humanities, and group B consisted of 111 students taking advanced foods and nutrition courses. The response rate was very good — 95 percent — because the questionnaires were distributed and collected in the classroom.

The conclusions about snacking and vending machine use are based primarily on the total population in the study, but some data for groups A and B are given in the tables. Most of the students were sophomores, juniors, and seniors (Table 1). As might be expected from general enrollment patterns, group B students were predominantly female.

Snacking behavior

During a 24-hour period almost all of the students had something to eat or drink between meals — 92.8 percent of the males and 91.7 percent of the females (Table 2). A large majority of the students obviously relied on snacks to complement, or even replace, their regular meals. More than a fourth bought their snacks from vending machines.

The most popular time to snack was during the evening, and the least popular between breakfast and lunch (Table 3, section A). Female students were more inclined than males to snack in the evening. Skipping

Table 1. — Distribution of Students in This Study by Sex and Student Classification

Classification	Total, N = 249		Group A, N = 138		Group B, N = 111	
	Male	Female	Male	Female	Male	Female
			percent			
Freshman	15.9	9.4	18.6	19.0	. .	2.0
Sophomore	27.5	25.6	30.5	35.4	10.0	17.8
Junior	29.1	35.0	33.9	20.3	. .	46.5
Senior	27.5	30.0	17.0	25.3	90.0	33.7

Mahmood A. Khan is assistant professor of food service management in the Department of Foods and Nutrition.

Table 2. — Percentage of Students Using Snack Foods and Vending Machines

Description	Total, N = 249		Group A, N = 138		Group B, N = 111	
	Male	Female	Male	Female	Male	Female
			percent			
Students using snack foods	92.8	91.7	80.0	90.1	94.9	93.7
Students using vending machines	28.1	26.1	30.4	27.0	12.5	25.3

Table 3. — Periods When Students Snacked and Used Vending Machines

Time	Total, N = 249		Group A, N = 138		Group B, N = 111	
	Male	Female	Male	Female	Male	Female
			percent			
A. Snacking						
Between breakfast and lunch	25.0	30.9	25.0	21.6	25.0	38.5
Between lunch and supper	53.1	60.6	55.4	66.2	37.5	56.0
Between supper and breakfast	79.7	90.3	83.9	93.2	50.0	87.9
B. Vending-machine use						
Between breakfast and lunch	16.7	18.6	17.6	20.0	..	17.4
Between lunch and supper	44.4	39.5	41.2	40.0	100.0	39.1
Between supper and breakfast	44.4	51.2	47.1	45.0	..	56.5

meals was common among the students in this study; 35 percent missed at least one meal, usually breakfast, during the designated period. Snacking and skipping meals definitely seem to go hand in hand.

The nutritional implications of these meal-skipping patterns have yet to be analyzed. But nutritionists and others interested in the health of young people are concerned that many students may not be getting an adequate diet.

Vending-machine use

Students tended to use the vending machines more between supper and breakfast, the period of heaviest snacking, than at other times of the day (Table 3, section B). About half of the evening snackers purchased food and beverages from vending machines.

An interesting finding is that 22.2 percent of the males and 30.2 percent of the females used vending machines more than once within 24 hours. Apparently when vending machines are near at hand, as they are on campus, students are likely to give in to the urge to snack. This finding merits further study.

Sixteen different types of food and beverages with 44 brand names were purchased from self-service dispensers. Carbonated beverages headed the list for more than two-thirds of the students. Nationwide, soft drinks are a popular snack item, and the University of Illinois is no exception. According to USDA figures for 1977, soft-drink sales in the United States totaled $11.5 billion, with a per-capita consumption of nearly 34 gallons. This quantity contains about 24 pounds of sugar.

After carbonated beverages, students purchased candy and gum most often. Other snacks included coffee, popcorn, chips, pretzels, pies, yogurt, fresh fruit, hot chocolate, crackers, and white and chocolate milk. Although a few of these snacks are nourishing, most of them have "minimal nutritional value" as defined by USDA.

The study of young people's eating habits is an ongoing project that will eventually give us many important details about snacking patterns. Currently, various snack foods are being evaluated to correlate their nutrient content with the percentage of the recommended daily allowance in them. Under study are intrinsic factors related to the type of snacks and their appearance, color, texture, and flavor. We are also studying extrinsic factors such as time, place, environment, access to vending machines, and effect of nutrition education on snacking habits.

Automated nutrition

For better or worse, vending machines are here to stay. How well they serve the public does not have to be left entirely to whim or the self-interest of vendors. The information gathered thus far indicates that vending machines can be an efficient and economical way to serve nourishing snacks and meals.

Not many employees are needed to maintain and stock self-service dispensers. With several machines supplying a wide selection of foods, the long lines in cafeterias during peak hours can be reduced. Moreover, vending machines may require less energy than the open warming and cooling units typically used in cafeterias, but this assumption has not yet been tested.

Automated food service does have some disadvantages. The machines occasionally break down or are vandalized. Food can spoil, and the microwave ovens provided for warming can be misused. With adequate supervision, however, these are not major problems.

Although we do not yet have much information about how vending machines influence snacking, we can begin to explore ways to make them work for rather than against us. Stocked with wholesome snacks, they can be used indirectly for nutrition education and for altering food selection patterns.

Feeder Pig Diseases

G. T. WOODS, M. E. MANSFIELD, and M. HAMOUD

ILLINOIS is second only to Iowa in swine production. Over the years the industry has been growing steadily, and with this growth has come increased specialization. An important segment of the industry is the production of feeder pigs, which are raised to 40 or 50 pounds and then sold at about 10 weeks to other farmers to fatten.

The state now has more and bigger feeder-pig enterprises than ever before. In addition, almost half a million young pigs are imported into the state each year for finishing. Expansion of this part of the Illinois livestock industry has occurred gradually as a result of cooperation among Extension personnel, organized farmers' groups, industry fieldmen, marketing specialists, and local veterinarians.

As a protection to farmers and consumers alike, feeder-pig dealers must be licensed by the Illinois Department of Agriculture, Bureau of Disease Control. At present, Illinois has 182 licensed dealers, with 223 licensed agents working for them. Official veterinarians at marketing centers inspect all feeder pigs offered for sale.

Unfortunately some pigs may appear healthy, yet have one of the chronic swine diseases, such as pneumonia or rhinitis. Sometimes these diseases do not show up clinically until the pig is well into the fattening period, which usually lasts about three months. Studying some of the disease problems was the subject of recent experiments conducted at the College of Veterinary Medicine and the Dixon Springs Agricultural Center.

Upon arrival

In the first of three experiments we evaluated 80 feeder pigs, 20 from each of four producers; the second and third experiments included a total of 160 pigs, 40 from each of four producers. When purchased at auction, the pigs weighed an average of 40 pounds each. Pigs from the individual producers were grouped in separate pens in an open-front finishing building equipped with a hand-operated flush system using recycled water from a lagoon. Every pig was identified with a plastic, button-type ear tag.

Samples of blood, feces, and nasal secretions were collected, and the entire lot was inspected for lice and mange. One or two animals from each producer were killed and examined for signs of pathology. Specimens from these pigs were cultured for *Salmonella* spp. Lung tissue was collected for histopathologic examination for enzootic pneumonia and migrating larvae of the common swine roundworm.

Many of the incoming feeder pigs had lice, mange, and heavy infestations of roundworm, but stomach worms and whipworms were rare. Early enzootic pneumonia was frequent, with *Mycoplasma* spp. the most common isolate, followed by *Bordetella bronchiseptica*. Of all the pigs examined, those from only a few farms were free of mycoplasma, bacteria, and parasites. No *Salmonella* spp. were isolated from the cultured tissue.

During finishing

Illinois 16 ration, which contains 16 percent protein, was fed to the pigs in all three trials. The feed used was weighed. From the time of arrival until the pigs reached 75 pounds, Mecadox was added to the feed to prevent swine dysentery. Untreated groups were compared with pigs receiving ASP-250 and virginiamycin, two medications that are often added to feed. The pigs were weighed midway in the fattening period and just before marketing. At weighing time, nasal secretions and blood samples were collected.

During fattening, any animal that died was carefully examined if not too badly decomposed; the carcass was then incinerated. We treated acute pneumonia in a few pigs, but several died before treatment. Many of the pigs that were free of *Mycoplasma* spp. and *Bordetella* spp. upon arrival soon became infected with organisms from carrier pigs in other lots. All of the *Bordetella* species detected were resistant to sulfonamides.

At slaughter inspection

Enzootic pneumonia was found in about half of the market-weight pigs inspected after slaughter. Pleurisy and pericarditis were infrequent, but pigs in the first trial often had atrophic rhinitis. Arthritis was not a problem. None of the pigs had detectable antibodies to swine influenza or pseudorabies upon arrival at the finishing building or just before marketing. In addition, the pigs were not infected with *Hemophilus suis,* a serious pathogen of swine.

Many of the livers had to be condemned because of scarring resulting from infestations of the common swine roundworm. Compared with pigs in the control lots, those fed ASP-250 showed a statistically significant weight gain.

Improving herd health

Many feeder pigs have bacterial and parasitic diseases that are both chronic and costly. But the problems can be remedied and herd health practices improved. In the long run, healthy feeder pigs that stay healthy during finishing will reduce production costs.

G. T. Woods is professor of veterinary microbiology, public health, and research; M. E. Mansfield, professor of veterinary Extension and research; and M. Hamoud, research assistant in the Department of Pathology and Hygiene, College of Veterinary Medicine. The cooperation of other researchers is gratefully acknowledged. This work was supported in part by the Illinois Department of Agriculture Swine Disease Research Fund.

Improved Processing Methods For Tender, Juicy Meats

LOUIS W. SOLOMON and GLENN R. SCHMIDT

BETWEEN slaughterhouse and table, a fifth of the meat we eat is processed for added flavor and tenderness. Sausages, hot dogs, and lunch meat are only a few of the many popular products made from fresh meat. During processing, the meat may be injected with curing solution, chopped, tumbled, and heated.

Each product has its own method of preparation. For example, meat is coarsely ground for pork sausage and finely ground for wieners. Products such as bacon, corned beef, and canned ham are not ground, but are cut and shaped in other ways. By using improved methods, processors have been able to offer consumers a wide selection of products for enjoyable eating.

Tumbling experiments

In the commercial preparation of canned ham, the meat is injected with a curing solution of salt, phosphate, spices, water, and nitrite (a preservative), cut into chunks weighing 4 to 8 ounces, and put into a tumbler at 12 revolutions per minute for several hours (Fig. 1). As the drum rotates, the meat is picked up on baffles, carried to the top of the drum, and then dropped to the bottom. Upon impact, the muscle fibers are damaged, causing an exudate of a sticky protein material to form on the surface of the meat.

After tumbling, the chunks are molded into the desired shape and cooked. The heat causes the exudate to bind the chunks into a solid mass that is easy to slice. Ham prepared in this way is more tender and gives better cooking yields than unprocessed ham.

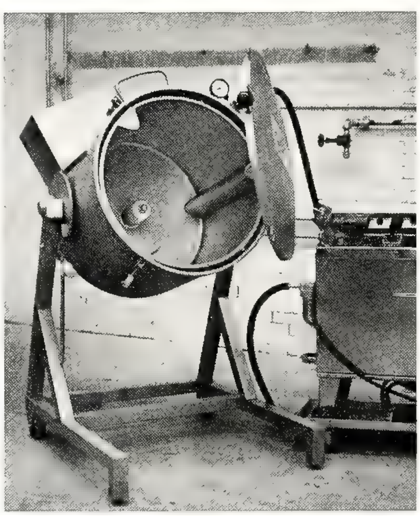
Louis W. Solomon is research assistant and Glenn R. Schmidt, associate professor of meat science.

Normally meat is not processed until many hours after slaughter. In the interval before processing, the muscle loses some of its flexibility, a condition known as rigor mortis. Meat is in a prerigor state while still soft, and in a postrigor state after becoming slightly less pliable.

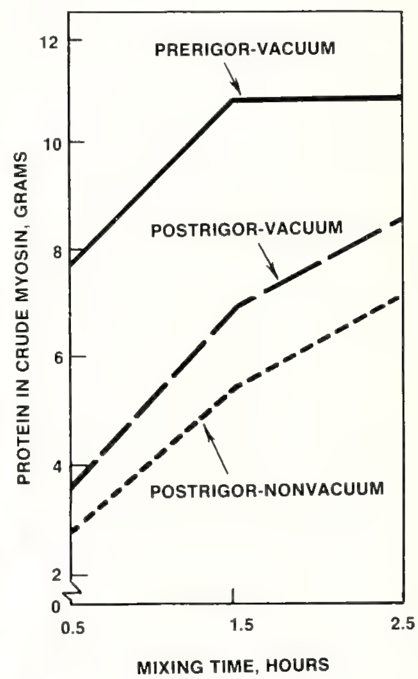
We conducted tests to find out how quickly prerigor and postrigor meat will absorb the curing solution with and without vacuum in the tumbler. Rather than being injected, the curing solution at 18 percent of the muscle weight was put directly into the tumbler with the meat. In these tests whole muscles instead of smaller chunks were used. The tumbler rotated for 13 hours and remained at rest for an additional 11 hours.

The concentration of salt (sodium chloride) absorbed from the curing solution was sampled six times in the outer, middle, and inner layers of the muscle (depths 1, 2, and 3). After 1 hour the outer portion contained 2.2 percent salt. However, even after 24 hours the salt distribution in whole muscles was not homogeneous.

Mean differences in salt content between prerigor and postrigor states and between vacuum and nonvacuum tumbling are shown in Table 1. The data were averaged for each sampling depth over all sampling periods. At depth 1, prerigor meat absorbed 0.28 percent more salt than did postrigor meat, and vacuum-tumbled meat absorbed 0.2 percent more salt than did the nonvacuum. These percentages represent 12.6 and 9 percent of the mean for the outer layer. At depth 2 the vacuum difference was 0.17 percent, and at depth 3 the rigor difference was 0.06 percent, or 28.8 and 33.3 percent of the respective means.



Meat tumbler used to test effects of rigor and vacuum state on cure uptake. (Fig. 1)



Effect of mixing time, rigor and vacuum state on crude myosin extraction. (Fig. 2)

These results clearly show that the vacuum and prerigor states independently increased salt absorption, thus cutting by about 3 hours the time required for cure uptake during tumbling. Although we used whole muscles in these tests, it is reasonable to assume that a desirable product with satisfactory cure distribution can be produced when smaller chunks of prerigor meat are vacuum tumbled.

Extraction of crude myosin

In another common processing method, chopped meat and salt are mixed to extract salt-soluble proteins. The main component of these proteins is myosin, which enhances the functional properties responsible for such qualities as texture, increased cooking yield, and improved binding in products made from finely ground meats.

We wanted to find out if vacuum, mixing time, and prerigor state hasten myosin extraction and improve functional properties. Prerigor hamburger and a salt solution were vacuum and nonvacuum mixed in a paddle mixer for 0.5, 1.5, and 2.5 hours. The same procedure was used for postrigor meat. After mixing, the crude myosin (CM) was isolated, then measured and compared across methods.

The results were encouraging (Fig. 2): 67 percent more CM was extracted with the prerigor-vacuum than with the postrigor-vacuum treatment ($P < 0.01$), and 12 percent more with the postrigor-vacuum than with the postrigor-nonvacuum treatment ($P < 0.05$). An increase in mixing time caused a linear increase in CM production for all treatments ($P < 0.01$). These findings suggest that prerigor state, vacuum, and extended mixing time increase the CM yield, which will improve processed products.

Tests of functionality

Binding ability and water retention are the most important functional properties of processed meats. To assess these characteristics for each CM preparation, we did a binding-force test and a gel test.

In the first of these tests, the CM preparation at a controlled protein concentration was spread between two slices of meat 0.8 inch thick; the "sandwich" was then cooked. Upon heating, CM forms a gel that binds, so that when the meat is thinly sliced with a special apparatus, the sections should hold together tightly. The force necessary to break this bond was measured and recorded by an Instron Universal Testing Machine equipped with pneumatically powered jaws.

We found that increased mixing time caused a decrease in binding (Table 2). Averaged over all treatments, the binding force decreased 51 grams per hour of mixing. Many processors believe that postrigor meat is better for processing than prerigor meat, but neither rigor state nor vacuum state had any apparent effect on binding force.

The gels formed after heating a CM solution for an hour have the ability to bind water, which increases the juiciness and cooking yields of processed meats. The lower the protein concentration required to form a stable gel the better, because less CM will be needed to bind water. In the gel tests, the protein concentration at which a stable gel remained in an inverted test tube varied with mixing time and rigor state, but not with vacuum state (Table 3).

Increased mixing time caused a decrease in CM functionality, as seen by the higher concentrations of crude myosin needed to form a stable gel. With postrigor treatments, CM preparations mixed for 0.5 hour gelled at a protein concentration of 4 milligrams per milliliter. Increasing the mixing time to 1.5 hours produced a stable gel at a protein concentration of 8 milligrams per milliliter. With prerigor-vacuum treatment, CM preparations mixed for 0.5 hour gelled at the lowest protein concentration. These tests demonstrate that CM mixed for 0.5 hour can hold more water in a gel at a given protein concentration than CM mixed for 2.5 hours.

Although more crude myosin is produced the longer the meat is mixed, CM preparations lost some of their binding and water-retention ability when the mixing time was increased up to 2.5 hours. Thus the gains have to be weighed against the losses. In general, however, the quality of processed meats will be improved by using prerigor meat under vacuum conditions.

Table 1. — Mean Differences for Salt Absorption as Influenced by Rigor and Vacuum States

Preparation	Sampling depth 1	2	3
		percent	
Overall mean[a] . . .	2.21	0.59	0.18
Prerigor — postrigor[b]	0.28**	0.06	0.06*
Vacuum — nonvacuum[b] . . .	0.20*	0.17*	0.05

[a] Mean of six sampling times.
[b] Mean differences of six sampling times.
** $P < 0.01$.
* $P < 0.05$.

Table 2. — Binding Force of Crude Myosin Binders

Preparation	Mixing time, hours[a] 0.5	1.5	2.5
		grams[b]	
Postrigor-vacuum	418.2	340.5	284.1
Postrigor-nonvacuum .	384.5	279.9	323.5
Prerigor-vacuum	391.6	465.2	281.7

[a] Binding strength in all treatments decreased over time ($P < 0.05$).
[b] Grams of force necessary to break binding junction of meat slice bonded by crude myosin.

Table 3. — Effect of Rigor State, Mixing Time, and Vacuum on Least Concentration Gel Tests of Crude Myosin

Preparation	Mixing time, hours	Protein concentration, mg/ml 2	4	6	8	10
Postrigor with or without vacuum[a]	.5	—[b]	+	+	+	+
	1.5	—	—	—	+	+
	2.5	—	—	—	+	+
Prerigor-vacuum .	.5	+	+	+	+	+
	1.5	—	—	+	+	+
	2.5	—	—	—	—	+

[a] There was no difference in gelling ability between vacuum or nonvacuum postrigor treatments.
[b] + denotes that gel of heated crude myosin solution is stable when test tube is inverted; — denotes that gel is unstable.

Nitrogen-Fixing Trees and Shrubs

J. O. DAWSON

Uninoculated and inoculated European alders in a nitrogen-free culture. (Fig. 1)

In the past, Americans have had abundant forest resources to satisfy most of their wood and fiber needs, but this situation is not likely to continue forever. Someday, intensive silvicultural systems using short rotations of rapidly growing trees will be necessary. The practice will probably become as common in the United States as it is today in other parts of the world.

Nitrogen-fixing trees and shrubs show promise for use in short rotations and on marginal lands. Grown as crops, these woody plants are an effective way to improve soil and to reclaim abused land so that it can support native species or valuable timber trees.

Nitrogen fixation is a natural process by which certain organisms take nitrogen from the air and convert it into a form that plants can use as a nutrient. Only a handful of bacteria, algae, and actinomycetes among all living creatures are capable of this process.

A common and efficient arrangement for nitrogen fixation occurs when specific microorganisms form nodules on the roots of plants. In the symbiotic relationship thus established, the host plant provides photosynthetically fixed carbon to the nodular organisms (endophytes), which in turn provide fixed nitrogen to the host plant. Nitrogenous materials are released into the soil through leaching, exudation, and the decomposition of host-plant tissues, thereby increasing the availability of nitrogen to associated plants.

Woody legumes

The nitrogen-fixing symbioses famaliar to most people are those between Rhizobial bacteria and herbaceous legumes such as soybeans, clover, and alfalfa. But many trees and shrubs are also members of the legume family. They are classified this way because they produce the flowers and pods characteristic of the Leguminosae family and may harbor nodular organisms that fix nitrogen.

Native and imported woody legumes can be found throughout Illinois. Black locust (*Robinia pseudoacacia*), for example, is native to southern Illinois, but has become widely established in other parts of the state. This species survives better on very acid spoil banks than any other tree species planted there, except perhaps European alder (*Alnus glutinosa*). For this reason, and because black locust fixes nitrogen, the tree has been widely used for mine-spoil reclamation and soil stabilization on severely disturbed and eroded sites.

Woody nonlegumes

Aside from the legume family, there are hundreds of nonleguminous species in eleven other families of vascular plants that are known to form root-nodule symbioses with nitrogen-fixing endophytes. Virtually all of these symbioses involve actinomycetes of the genus *Frankia,* which have both bacterial and fungal characteristics. Very few nonwoody plants form nodules when infected with actinomycetes.

Only recently has the actinomycetal microorganism been isolated and susceptible host plants infected with the isolate. With the work of Dale Callaham and colleagues in John Torrey's laboratory at Harvard Forest in Petersham, Massachusetts, isolation of the *Frankia* endophyte has opened the door to more refined studies of this symbiosis.

Comprised of fourteen genera, the group of actinomycete-nodulated plants to which alders (*Alnus* spp.) belong is genetically diverse, indicating that the relationship between host and endophyte is more flexible than in the legumes. If transfer of nitrogen-fixing ability to other groups of woody plants is to be attempted, *Frankia* rather than *Rhizobium* endophytes associated with legumes should be tried. The *Frankia* group includes species native to many geographical areas and forest habitats. Wide utilization in forest culture is therefore possible.

The importance and potential usefulness of nitrogen-fixing vascular plants other than members of the legume family has not been generally recognized. Yet these plants have been vital in the nitrogen economy of terrestrial ecosystems for millions of years.

During the four recent, major glacial advances in the northern hemisphere, it is likely that nitrogen-fixing nonlegumes such as *Alnus* and *Dryas* were primarily responsible for the colonization of raw glacial till and the original build-up of soil nitrogen over vast areas of Europe, Asia, and North America.

Evidence indicates that early peoples of Central America used nitrogen-fixing nonleguminous trees in their agricultural practices. According to Jock Green, a graduate in forestry from Iowa State University

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J. O. Dawson is assistant professor of forestry. Partial funding for this project was provided by the North Central Forest Experiment Station of the USDA Forest Service, under the auspices of the Program for Maximum Yield of Wood and Energy from Plantations.

and a Peace Corps volunteer in Guatemala: "The people have, for how long I don't know, recognized that an alder left here and there in the corn field makes the corn grow better. . . . There are two species native to the mountains where this practice occurs: a river-bottom and a highland variety." These species are probably *A. arguta* and *A. firmifolia.*

Forest soils, as well as agricultural lands, more often than not are deficient in nitrogen in a form that can be taken up and metabolized by plants. Thus the nutrient most frequently added artificially to increase the productivity of forest soils is nitrogen in the form of nitrate, urea, or ammonia.

Recently, however, the cost of these fertilizers has increased sharply with the price of natural gas and petroleum, which are used extensively in fertilizer manufacture. In the future, food production will probably be given preference over wood and fiber production for the limited supplies of nitrogen fertilizer. If supplies have to be restricted, wood-using industries should be interested in nitrogen-fixing plants as a way of improving wood yields to meet increased demand for raw materials.

Ample precedence has been established for using alder and other nonleguminous, nitrogen-fixing woody plants in forestry, much as legumes are used to improve the productivity of agricultural soil. Documented cases of soil improvement exist for eroded areas, a variety of mining spoils, exhausted farmland, exposed road cuts, peat lands, sand dunes, and raw humus with an iron pan.

In addition, growth rates for forest trees of several families have been improved through association with nitrogen-fixing nonlegumes. Benefits have been reported for ash, sweetgum, poplar, tulip tree, spruce, Douglas fir, black walnut, and apple.

Alders

Although Illinois has many native and imported, nonleguminous, nitrogen-fixing woody plants, some may prove to be more valuable than others for soil enrichment and timber yields. The most commonly planted alder in Illinois is European alder (*A. glutinosa*), which thrives in moist soils, although it can also grow well on drier sites. Its seeds have an air bladder that causes them to float. Consequently, naturalized stands have sprung up in Du Page and Champaign Counties from plantings along streams.

Unlike the small native alders, European alders often grow to 100 feet in height and 3 feet in diameter on choice sites. Because of the rapid growth rate and fiber characteristics suitable for pulp-mill needs, Westvaco timber company has established European alder plantations on bottomland sites in southern Illinois and Kentucky. European alder has also been planted for bank stabilization at an Illinois Power Company reservoir near Clinton, and for reclamation of mine spoils on Erie Mining Company land in northern Minnesota.

Table 1. — Effective Combinations of European Alder and North American Frankia

Host plant	Source of inoculum		
	Isolate	Crushed nodules	Other
Alnus glutinosa . . . . Clone 3-21 Clone 2-50	*A. crispa* from Canada *Comptonia peregrina* from Massachusetts	*A. serrulata* from Illinois *A. rugosa* from Iowa *A. rubra* from Oregon	Low-slope coal-mine spoils from Danville, Illinois
A. glutinosa . . . . Unspecified	. . .	. . .	Various soils from Iowa, Illinois, Indiana

North American sources

With so many beneficial qualities, European alder has considerable potential for intensive silvicultural use and mine-spoil reclamation in Illinois. But the possible gains from effective management of alder extend beyond the state boundaries. Therefore, the Department of Forestry at the University of Illinois has cooperated with the U.S. Forest Service in researching the physiology of the alder-actinomycete symbiosis.

Our studies have shown that both host plant and endophyte genotype can influence the growth performance of alder. Clonal lines, derived from greenwood stem cuttings rooted under mist in the greenhouse, were developed from trees that are hardy and vigorous in Illinois. These lines exhibit similar relative growth rates whether nitrogen is obtained from combined sources such as nitrate or ammonium ions or from actinomycetal nitrogen fixation in nodules.

However, North American sources of the *Frankia* endophyte often take slightly longer than European sources to produce visible nodules on European alder. The result is a delay in growth, which suggests genetic differences.

Despite this delay, geographic separation has not resulted in incompatibility between European alder and *Frankia* from a wide variety of North American sources (Table 1). All nodules produced from these combinations showed nitrogen-fixing capability when assayed by the acetylene-reduction method.

Inoculation for our purposes was done (1) with surface-sterilized nodules ground and diluted in distilled water, (2) with soil containing the *Frankia* actinomycete, or (3) with the *Frankia* isolate grown in a nutrient medium. Alders that are not inoculated fail to grow in a nitrogen-free, hydroponic medium (Fig. 1).

The search continues for combinations of *A. glutinosa* and *Frankia* endophytes that couple efficiently to fix nitrogen and produce fiber. Other species of alder also under investigation may eventually be useful for reclamation, making difficult sites productive, and rapidly producing timber.

Ginkgo: A Beautiful Tree With Edible Seeds

ROBERT M. SKIRVIN and MEL C. CHU

DURING THE AGE of the dinosaur millions of years ago, ginkgoes grew throughout the temperate areas of the world. Today only one member of the entire Ginkgoaceae family survives: *Ginkgo biloba* Linn., which strictly speaking is not closely related to any other living plant species. Because the ginkgo so closely resembles its fossilized relatives, it is often called a "living fossil."

Desirable as an ornamental

Known to some people by the name maidenhair tree, the ginkgo is a large, long-lived, and beautiful ornamental. When mature it may reach 120 feet or more in height and 12 feet in girth.

The growth habit is unusual: "In youth it has a continuous central column, and is sparsely branched with the spire-like or pyramidal habit of cone-bearing trees. As it becomes older its form is more or less conical. The main shaft usually divides and the crown is made of several large ascending and spreading branches and many horizontal or somewhat drooping branchlets" (as described by Warren Brush in *American Forests*, 1947).

Landscapers are particularly interested in these trees because they do not seem to have any serious insect or fungal pests. The ginkgo also appears to be insensitive to several forms of air pollution and to adverse soil conditions. Hence ginkgoes are often used as street trees either alone or in groups.

The incised, fan-shaped leaves, which are found in no other flowering plant, turn a brilliant, glossy yellow in the fall. Plantings of ginkgo and maple trees provide superb autumn scenery.

The ginkgo has a very long life span. In the gardens of certain Chinese and Japanese temples some specimens are reputed to be more than 1,000 years old. Because of its long life, the Chinese call the ginkgo "Kung Sun Soo," which means "grandpa grandson tree."

The wood is soft and lightweight but finely textured. In oriental countries it is used for buildings, boats, furniture, wood carvings, drawing boards, and paper.

Propagation

Ginkgo trees are either male or female. The fruit of the female resembles an apricot in size and color. But the similarity ends there; when the fruit begins to decompose, it gives off a highly offensive odor. Sidewalks become slippery with the decaying pulp, and some people develop a rash, much like that caused by poison ivy, when the juice touches their skin.

Planting only male trees is necessary to avoid this unpleasant situation

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during the fall. Ginkgoes would undoubtedly be more popular than they are if propagators could be sure of obtaining only male trees quickly and economically. Seed propagation is unsatisfactory, however, because the sex of a ginkgo cannot be determined until after the tree flowers at twenty years or more of age.

To obtain only male ginkgoes the propagator must use asexual techniques such as layering, grafting, and cuttings. Layering is seldom used because generally only young ginkoes, whose sex cannot be determined, have branches low enough to be bent and buried in the ground for rooting.

Grafting spurs from known male trees onto seedling rootstocks in early spring is a sure way to obtain males, as is shield budding, a method for implanting a leaf bud within a small slit in a branch. However, both techniques are rather expensive for large-scale propagation because they are time consuming and must be done by an experienced propagator. At current prices, guaranteed male trees 5 to 7 feet tall cost about $50 each.

Cuttings may prove to be a useful way for commercial propagation. We have found that up to 50 percent of the cuttings gathered in June rooted within 60 days, while none of the ones taken in late August rooted. The rate improved considerably when the cuttings were dipped for 5 seconds in indolebutyric acid (IBA) in a 50-percent alcohol solution. With IBA at a strength of 5 grams per liter, 90 percent of the June cuttings and 50 percent of the August cuttings rooted. At 2.5 grams IBA the success rate was 75 percent for June cuttings. Cuttings from new shoots rooted most easily. Spurs that were more than two years old also rooted, but at only half the rate of newer shoots.

The use of tissue cultures from shoots or leaf buds may be another answer to the problem. We have found that shoots can grow in several media, such as Murashige and Skoog, Linsmaier and Skoog, and White's. All solutions were supplemented with 2 milligrams per liter of 6-benzylaminopurine, 0.1 milligram of α-naphthalene acetic acid, 50 milligrams of ascorbic acid, and Staba vitamins. Rooting with various media formulations is still in the experimental stage, however.

Seedlings can of course be obtained through embryo culture with little difficulty, but there is no assurance that male seedlings will be produced.

Bonsai specimens

Dwarfed or bonsai ginkgoes make beautiful indoor plants. Skillfully pruned and cared for, a pot-grown ginkgo will stand no more than 2 feet high when it is forty years old. Fresh seeds should be used for this purpose. The seeds will not usually germinate immediately, but require a period of afterripening to allow the immature embryo to develop. It is unnecessary to clean the fruit before sowing the seed.

A bonsai ginkgo will naturally drop all its leaves in the fall because it is a deciduous tree. During the tree's dormant stage the soil should be kept moist so that new leaves will emerge the following spring.

Edible seeds

Despite the unpleasant qualities of the fruit, the nut or seed inside is good to eat and is used in oriental dishes or as a snack food. The seeds can be purchased canned in water at oriental food stores, or the fruit can be gathered fresh as it ripens in autumn. When gathering the fruit, however, people who are allergic to it should wear rubber gloves to prevent a rash.

To prepare the seeds, the offensive fleshy layer must first be removed by soaking the entire fruit. After a day or two it can be mashed and the flesh washed away under running water. Any lingering odor can be removed by soaking the seeds in a solution of 1 tablespoon of baking soda to 1 gallon of water for half an hour. Repeat the soaking process if necessary.

Like most other nuts, ginkgo seeds can be roasted. To do so, place the clean, dry, unshelled seeds in an open pan and bake for about 15 minutes at 350°F until lightly browned. Serve either hot or cool. Do not eat more than a few ounces at a time, because too many seeds may be difficult to digest.

With a flavor similar to mild Swiss cheese, ginkgo seeds are a tasty addition to dishes such as duck or chicken. To prepare, boil the unshelled seeds for 10 to 15 minutes. Let dry, then remove the thin shell with a nut cracker and add to the meat sauce. In oriental cooking, ginkgo seeds and chestnuts are often used together.

The nutritional composition of ginkgo seeds, as analyzed by the U.S. Department of Health, Education, and Welfare, is presented in Table 1. Compared with peanuts and walnuts, the seeds are low in protein, but they are a good source of essential vitamins and minerals and have fewer calories than most other nuts.

In the secluded parks and gardens of oriental countries, the decaying fruit is scarcely noticed during the few weeks it litters the ground. Although male ginkgoes are preferred in the United States, the females are to be prized for their edible seeds.

Table 1. — Composition of Ginkgo Seeds

	100 grams (3.5 ounces)	
	Fresh product	Canned in water
Refuse, pct.	24.0	0
Calories	185.0	126.0
Moisture, pct.	54.1	68.6
Protein, g	4.8	2.4
Fat, g	1.6	0.9
Carbohydrate (including fiber), g	38.1	27.1
Fiber, g	0.6	0.1
Ash, g	1.4	1.0
Calcium, mg	5.0	10.0
Phosphorus, mg	150.0	48.0
Iron, mg	1.2	0.5
Sodium, mg	7.0	320.0
Potassium, mg	523.0	160.0
B-carotene equivalent, mg	180.0	80.0
Thiamine, mg	0.24	0.07
Riboflavin, mg	0.12	0.02
Niacin, mg	2.8	0.1
Ascorbic acid, mg	25.0	0

Source: "Food Composition Table for Use in East Asia," from a research project sponsored by the U.S. Department of Health, Education, and Welfare, and the Food and Agriculture Organization of the United Nations. December, 1972.

WILDERNESS: Do Illinoisans Approve?

R. A. YOUNG and B. FLY

ONE of the most controversial issues in the management of our natural resources centers on how much wilderness should be preserved and how it should be managed. Public lands still contain millions of acres of wilderness that are not preserved by federal law. With the rapidly rising cost of lumber, considerable thought is being given to producing wood products from these forested lands. People opposed to this view argue that the areas might be put to better use by preserving them as wilderness.

Wilderness uses

At present federally protected wilderness areas are used for nonmotorized recreation, cattle grazing, fishing, hunting, and water production. Motorized travel, logging, and the construction of permanent facilities are prohibited. However, even wilderness users do not always see eye to eye on certain questions. Some users want no man-made changes except for a few primitive trails, while others would enjoy the wilderness more than they do now if the areas had better trails, a few crude tables, and signs.

Because the law is not specific about wilderness uses and because users vary in their preferences, managers have had few clear guidelines for making decisions. An important and often overlooked source of information to aid decision makers is the opinion of the general public. Collectively the public owns the wilderness and as individuals must pay for preserving additional areas through increased prices for wood products.

Illinois residents interviewed

To determine what percentage of the population uses the wilderness and how users and nonusers feel about preserving these areas, we conducted a telephone survey of 700 households randomly selected throughout Illinois. More than 500 of the interviews were completed. In this study, wilderness was defined as tracts of federally owned land, usually larger than 5,000 acres, open for recreational activities and livestock grazing, with no logging or motor vehicles allowed.

Respondents were asked if they are wilderness users. Only 4.6 percent, or 23 of the people surveyed, had ever visited a wilderness. Within the last five years, 8 of the users had not visited a wilderness, and 6 had visited such an area only once during that period. A few of the users reported visiting the wilderness more than once in the specified period, but no one had been there five times.

Both users and nonusers were asked how strongly they agree or disagree with eight statements:

— At present the amount of land in the wilderness system is too small.

— Roads and automobiles should be allowed in wilderness areas.

— It's good that wilderness areas exist and are being preserved.

— Some forest lands that were cut down for lumber 50 years ago could now be used as wilderness areas.

— Hunting wild animals should be prevented.

— If it would reduce the cost of wood and paper, cutting trees should be allowed.

— Wilderness areas should be abolished and the land used for resorts, logging, and similar purposes to create jobs in the area.

— Domestic livestock should be prevented from grazing in wilderness areas even if the restriction raises the price of meat.

Positive response

Half of the people interviewed approved of the wilderness concept; only 2 percent moderately disapproved, and 48 percent were neutral. In answer to the eight statements, 98 percent agreed strongly or moderately that it is good to have wilderness areas. Eighty-seven percent moderately or strongly disagreed that wilderness areas should be used for some other purpose even if new uses would create jobs in the area.

Most of the respondents approved of current wilderness uses, although 78 percent felt that hunting should be banned. Three-fourths thought that roads and motor vehicles should not be allowed. Two-thirds did not agree that cutting trees should be permitted even if doing so were to lower the cost of wood and paper, but about the same percentage felt that grazing is all right. Approval of grazing and disapproval of logging were apparently based on the activity itself rather than on the economic trade off.

In the opinion of 75 percent of the Illinoisans interviewed, lands that were cut over many years ago could now be used as wilderness. Most of the respondents in this sample said they do not use the wilderness; however, more than half said they would like to do so some day.

Users had different concepts of the wilderness than did nonusers, so to base management decisions and allocation policies on the opinions of users alone would be biased. Although the question of how much wilderness should be preserved was not answered, this study did indicate strong support for preserving additional wilderness areas.

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Lateral Resistance of Pole-Building Anchorages

J. M. CARSON and J. O. CURTIS

POLE OR POST FRAMES are commonly used in the construction of farm storage buildings. Structural problems may occur, however, when large buildings for storing modern farm machinery are built with conventional post anchorage systems designed for smaller structures.

Downward loads from snow and the weight of the building can make posts settle. Uplift loads from the wind tend to draw posts from the ground, and lateral loads, also from the wind, may cause posts to lean. A well designed anchorage system at the base of the poles should safely transmit these loads to the ground.

Seven systems tested

Posts in large farm buildings without concrete floors often do not have enough resistance to lateral loads because the anchorage system fails to hold the base of the post securely. Six improved systems were therefore designed and tested along with a control to determine how effectively they resist lateral loads (Fig. 1). Replicated twice, each system consisted of a dressed 6 × 6 post placed in a hole 12 inches in diameter and about 52 inches deep.

Fourteen holes were dug in undisturbed soil on the Agricultural Engineering Research Farm at the University of Illinois during the late fall of 1977. The topsoil was Flanagan silt loam to a depth of 24 inches over a subsoil of yellowish brown clay. Before the posts were set, water had to be pumped from most of the holes.

The lower part of all seven systems was formed by placing a half bag (45 pounds) of dry concrete mix in the bottom of the hole to form a 5-inch layer. Each post was set on this layer and the remaining half bag of dry concrete mix poured around the base of the post to form a 7-inch collar. About 3 inches from the bottom of the post, two ⅝-inch pipes 9 inches long had been inserted into holes drilled at right angles to each other to anchor the post in the concrete base.

Above the collar a different method was used to complete each system:

— The **control** system, filled with soil excavated from the hole, was backfilled in 6-inch layers, each of which was thoroughly tamped.

— The **half-bag** collar system was also filled with soil, but the top 7 inches of the hole were backfilled with a half bag of dry concrete mix to form a collar at the ground line.

— The **full-bag** collar system was like the half-bag except that the top 14 inches were backfilled with a full bag of dry concrete mix.

— The **crushed rock** system used a backfill of crushed rocks 1 to 2 inches in diameter.

— The **gravel** system used washed gravel ½ to 1 inch in diameter as backfill.

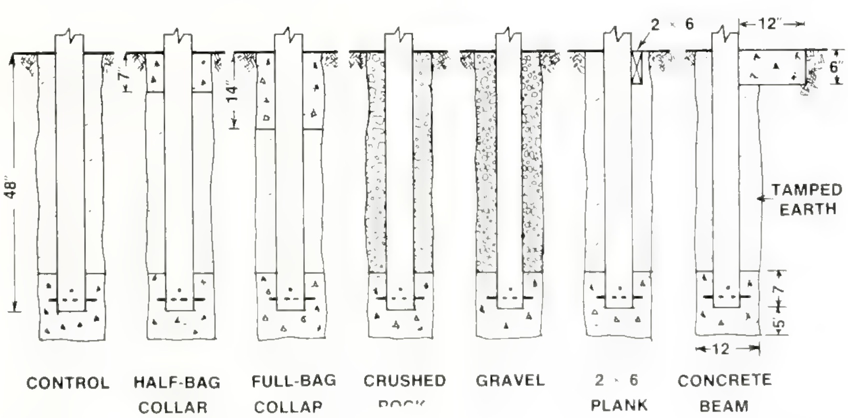
— The **2 × 6 plank** system was similar to the control except that a 2 × 6 plank 8 feet long was buried in a horizontal position next to the post. The narrow edge of the plank was flush with the surface of the ground.

— The **concrete beam** system was backfilled with soil and a 6 × 12-inch beam 8 feet long cast next to the post. The top surface of the beam was flush with the ground surface. This system was included to approximate the effect of a concrete floor next to the post.

Load test procedures

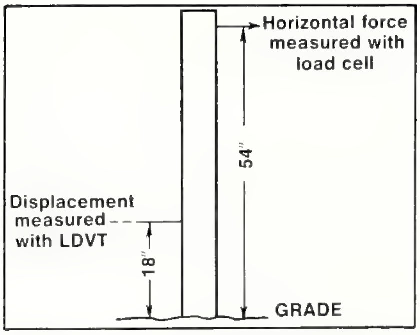
The soil was reasonably dry in August, 1978, when we conducted load tests on the fourteen posts, using a hydraulic cylinder and cable arrangement and a loading frame. In these tests we applied a horizontal load to each post 54 inches above grade at roughly 25 pounds per second until the post was deflected at least 3 inches at a height of 18 inches above grade or until the post broke (Fig. 2).

Magnitude of the load was measured with a 5,000-pound load cell, and horizontal displacement of the posts at 18 inches was measured with a linear displacement voltage transducer. The signals produced by the load cell and the transducer were fed into a plotter to obtain a load-displacement curve for each test.

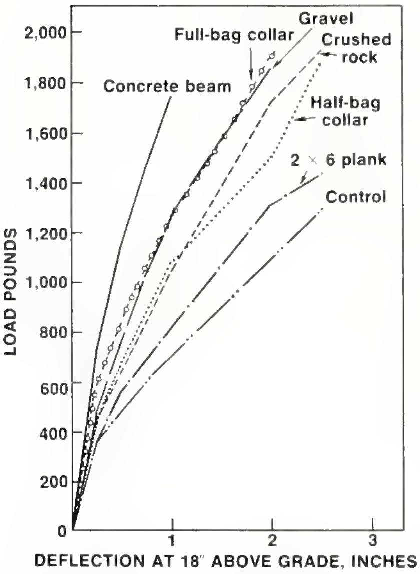


Types of post anchorage systems tested. (Fig. 1)

J. M. Carson is research assistant and J. O. Curtis is professor of agricultural engineering.



Position on post where deflection was measured with a linear displacement voltage transducer (LDVT). (Fig. 2)



Horizontal load measured at 54 inches above grade versus horizontal deflection at 18 inches above grade. (Fig. 3)

Concrete beam the strongest

Test results are shown in Figure 3 and Table 1. As the load deflection curves indicate, the control system is the weakest, the concrete beam the strongest, and the other systems intermediate in strength. The curves were obtained by averaging the horizontal load of the two replicates at deflections of ¼, ½, ¾, 1, 2, and 2½ inches. Horizontal loads for both replications of each anchorage system are given at deflections of ¼, ½, ¾, and 1 inch in Table 1.

To statistically test for differences in strength of the systems, the data were analyzed in a randomized complete block. Analysis of variance indicated a significant difference in strength of the anchorage systems. A least significant difference analysis (LSD) was performed to rank the relative strengths of the systems. In Table 2 the strengths of those systems connected by a straight line are not significantly different from each other at the 5-percent level.

The resistance to overturning provided by the seven systems is compared in Table 3 to the bending strength of a 6 × 6 post. Values of the moment of anchorage system forces that resist overturning were calculated at a horizontal post displacement of 1 inch at 18 inches above grade. Bending strength of a 6 × 6 post is 4,159.5 pounds feet, assuming the post is no. 1 grade Douglas fir or southern yellow pine with the allowable fiber stress for bending under a normal load of 1,200 pounds per square inch and with a 1.5 duration of load adjustment for wind loading.

A strength rating for each anchorage system was determined by dividing the resisting moment of the system by the bending strength of the post (thus for the concrete beam: 7,816.5 ÷ 4,159.5 = 1.88). If we assume that these ratings are comparable to a factor of safety and that a value in the range of 1.5 to 2.0 is desirable, the first six systems in Table 3 do not allow the full bending strength of a 6 × 6 post to be developed.

On the basis of these test results, we reached several conclusions:

1. Only the gravel, full-bag collar, and concrete beam systems were significantly stronger than the control.

2. The concrete beam system, which was used to simulate a concrete floor, was significantly stronger than all the other systems tested.

3. Only the concrete beam system provided the resistance necessary at the base of the post to develop the full bending strength of a 6 × 6 post.

4. In buildings without concrete floors, posts 6 × 6 or larger need an anchorage system stronger than any included in these tests if the full bending strength of the post is to be developed with a reasonable factor of safety.

Table 1. — Horizontal Loads for Anchorage Systems at Various Deflections

System	Replication	Deflection at 18" ¼"	½"	¾"	1"
		pounds			
Control	1....	400	600	760	910
	2....	300	375	450	500
Half-bag collar	1....	525	800	1,015	1,280
	2....	260	530	700	850
Full-bag collar	1....	700	1,000	1,200	1,400
	2....	450	700	900	1,080
Crushed rock	1....	425	670	875	1,075
	2....	450	650	825	1,000
Gravel	1....	525	825	1,100	1,325
	2....	450	700	950	1,175
Concrete beam	1....	800	1,250	1,550	1,775
	2....	650	1,050	1,400	1,700
2 × 6 plank	1....	360	550	700	830
	2....	350	550	670	800

Table 2. — Least Significant Difference Analysis for Relative Strengths of Anchorage Systems

System	Mean strength, pounds	LSD
Concrete beam	1,272	
Full-bag collar	929	
Gravel	881	
Half-bag collar	756	
Crushed rock	746	
2 × 6 plank	601	
Control	537	

Table 3. — Overturning Resistance of Anchorage Systems Compared to Strength of 6 × 6 Post

System	Resisting moment, pounds feet	Strength rating
Control	3,172.5	.76
Half-bag collar	4,792.5	1.15
Full-bag collar	5,580.0	1.34
Crushed rock	4,666.5	1.12
Gravel	5,625.0	1.35
2 × 6 plank	3,667.5	.88
Concrete beam	7,816.5	1.88

Some Corn Yields Top 200 Bushels

W. M. WALKER and D. W. DIBB

IF PREDICTIONS come true, Illinois corn yields will average about 120 bushels per acre this year. With improved practices a few growers have more than doubled this average.

Study of high yields

What production practices do growers use to get yields of 200 bushels or more per acre? To answer this question agronomists conducted a nationwide survey of corn producers and researchers who obtained unusually large yields. Summarized here are some of the findings for Illinois, which was included in the survey.

Fifty-one reports of 200 bushels or more per acre were received from Illinois. Yields ranged from 200 to 338 bushels, with an average of 219. The areas harvested were from 1 to 25 acres, but size of the area had no significant relationship to yield in Illinois or elsewhere in the nation. Some production practices related to the high yields are presented in Table 1.

Production practices

The earliest planting date was April 13 and the latest May 17; the average for the survey was April 30. Although the range is wide, it represents the earliest practical dates for planting from south to north in Illinois, which is about 400 miles long. All 51 producers who reported high yields recognized the importance of planting early, a practice that has been recommended for many years in this state.

Soil fertility must be adequate to produce corn yields of 200 bushels or more. In the Illinois part of the survey, increased levels of nitrogen, phosphorus, and potassium fertilizer were associated with high yields. Soil pH, a measure of soil acidity, varied from 6.0 to 6.8, with an average of 6.4. Illinois agronomists suggest a minimum pH of 6.0 in a cash-grain-crop production system. Data from the survey support that suggestion where yields of 200 bushels or more per acre is an objective.

Nitrogen rates varied more widely than might be expected. On the average, 1 bushel of corn contains about 0.8 pounds of nitrogen in the grain. Thus 200 bushels of corn contain about 160 pounds of nitrogen. Yet a few of the producers surveyed applied less than the amount removed by the grain. Decomposing crop residues may have supplied additional nitrogen. Other sources such as manure or a previous legume crop may also have added to the available nitrogen at some sites. According to our analysis, the correlation between rate of applied nitrogen and corn yield was positive, indicating that the high yields obtained in this survey were generally associated with high rates of nitrogen fertilizer.

The use of an adapted variety, along with adequate plant population, is another recommended practice. Producers in this study planted several different corn hybrids, so evidently many commercial varieties contain the genetic potential for 200-bushel yields.

Plant populations ranged from 21,000 to 40,000 plants per acre, with an average of 25,000. There was a significant, positive association between plant population and yield. Growers who want to obtain very high yields should therefore consider planting above-average populations.

Some agronomists and producers believe that planting in narrow rows is an important factor in achieving high yields. But neither the Illinois nor the national survey revealed any significant association between row width and corn yield. However, the average row width of 34 inches reported in Table 1 would have been considered unusually narrow a few years ago.

Other practices not evaluated in the survey are important for economic corn production. Adequate weed control is necessary, and potential insect and disease problems must be considered, along with climatic factors such as favorable moisture conditions. When available, irrigation at critical times during the growing season improves yield potential on many soils.

Recommendations

In reaching the 200-bushel mark, researchers and corn producers used many beneficial crop production practices, but early planting is one of the most important. In fact, it may be impossible to obtain high yields if planting is greatly delayed. Growers probably planted as soon as it was practical to do so on their farms. Late planters are not represented in the survey because they obtained less than 200 bushels.

Since fertilizer rate and plant population varied together, we were unable to separate their effects on high yields. It does seem reasonable that a higher plant population might have a greater requirement for nutrients than a lower population. Super yields are of course unusual, but if growers carefully follow recommended practices, their corn yields are likely to improve.

Table 1. — Production Practices Associated With Corn Yields of 200 Bushels or More Per Acre in Illinois

Variable	Minimum	Maximum	Average
Planting date	April 13	May 17	April 30
Plants/A.	21,000	40,000	25,000
Row width, inches	28	38	34
Nitrogen, lb./A.	24	600	197
P_2O_5, lb./A.	11	386	80
K_2O, lb./A.	6	526	85
pH	6.0	6.8	6.4
Yield, bu./A.	200	338	219

W. M. Walker is professor of biometry and soil fertility; D. W. Dibb is southern midwest director of the Potash and Phosphate Institute, which provided financial support for the survey.

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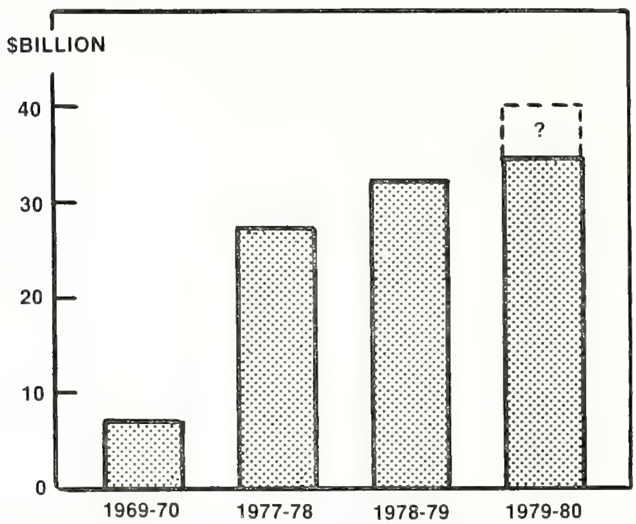
FARM BUSINESS TRENDS

THE EXPORT MARKET will be especially favorable in the year ahead because U.S. production of feed grains and wheat in 1979 was up while worldwide production was down from the previous year.

During the marketing year ending September 30, 1979, foreign buyers took 66 percent of the 1978 U.S. wheat crop, 28 percent of the feed grains (corn, sorghum, oats, and barley), and 54 percent of the soybeans and soybean products. Total value of U.S. agricultural exports during that year was estimated at $32 billion compared with $27.3 billion in 1977-78 (see graph). According to projections for fiscal year 1980, our agricultural exports will expand to between $35 and $40 billion. Feed grain shipments will increase by about 10 million tons and wheat shipments by nearly 6 million. Significant gains are also forecast for soybeans.

Exports will increase because of an expected substantial rise in Soviet Union grain purchases after the drop in their 1979 production, continued growth in livestock production in major export market countries, further expansion in rapidly developing countries, relatively little agricultural growth in less developed countries, and logistic problems and reduced feed grain supplies available for export in competing countries.



Total U.S. agricultural exports, 1969-70, 1977-80.

The brisk grain trade is expected to be a key factor in the prices U.S. farmers receive for wheat, feed grains, and soybeans in 1979-80. However, the ability of the U.S. transportation system to move supplies to port is a serious concern. Fuel, transportation, and general economic problems will put major restraints on our efforts to reach a record value of agricultural exports for the eleventh consecutive year.

Asia was our biggest market in 1978-79, importing $11.8 billion of U.S. agricultural products; Japan accounted for $4.9 billion of this amount and the People's Republic of China $900 million. Western Europe bought about $9.8 billion, Russia $2.3 billion, Latin America $3.1 billion, and Canada $1.7 billion.

U.S. agricultural imports totaled $16.3 billion in 1978-79 compared with $13.9 billion in 1977-78. The largest noncompetitive import was coffee at $3.9 billion, and the largest competitive import was meat and meat products at $2.5 billion. Meat imports rose about 15 percent in volume and 62 percent in value. All agricultural imports are expected to increase slightly in value during fiscal year 1979-80. Increases are anticipated for meat and meat products, coffee, fruits, vegetables, sugar, and rubber.

Recent trade negotiations will result in a net gain of about $400 million a year. Exports could eventually increase about $510 million and imports $106 million. The largest export increases are expected in livestock, livestock products, and oilseeds. In exchange for the trade concessions received, the United States granted other nations improved access to our market by increasing quotas for dairy products and reducing tariffs for beef, lamb, live cattle, inedible molasses, fruits, and vegetables. — *Harold D. Guither, professor of agricultural economics*

Spring, 1980

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

IN THIS ISSUE

Hens kept in this chamber maintained egg production with only five hours of intermittent light per day (page 7).

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE Volume 22, Number 2

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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(Cover picture by Paul Hixson)

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R. G. Cragle .... Director

Sheila R. Wiley .... Editor

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A NEW FRAME OF REFERENCE FOR RESEARCH

IMMEDIATELY AFTER WORLD WAR II, agricultural research expanded enormously in the United States, and with expansion came specialization. New information derived from these efforts provided the springboard for ever increasing production efficiency.

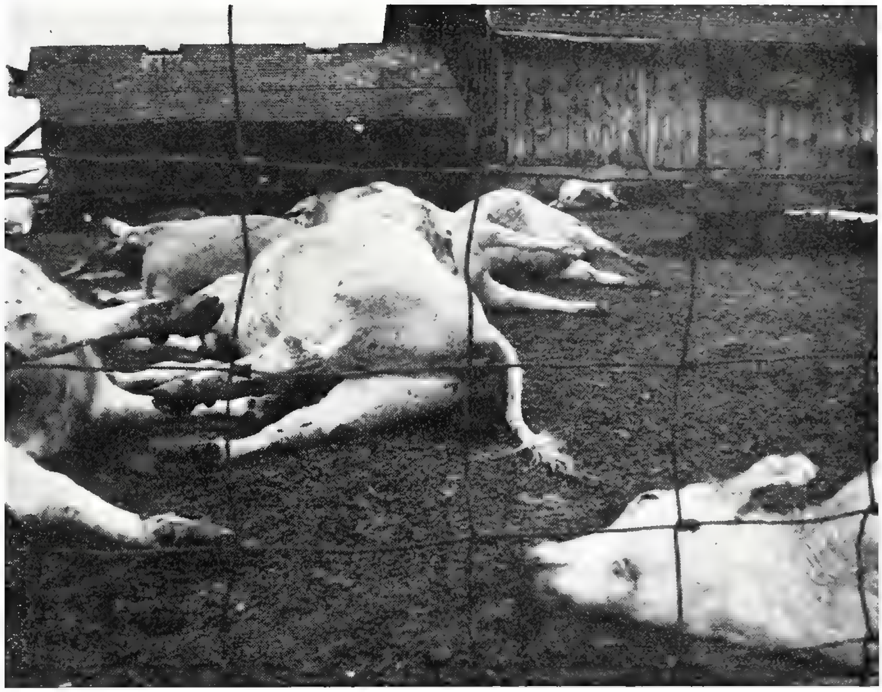
Until just a few years ago the system worked well, built as it was on a stable platform of abundant land, water, and energy, with little attention paid to possible side effects on the environment and society. But during the 1970s nearly every aspect of that platform began to shift. The basic rules have now changed and new relationships between research and production are rapidly taking shape. Reduced dependence on petroleum is the touchstone in a transition being felt throughout agriculture.

The time has come for us to be pragmatic in our research programs. We hear pleas for more basic research, but we also hear pleas for very practical work that will help the agricultural industry and our nation through a trying period of adjustment. During the decade ahead we cannot forget that guiding agriculture towards energy self-sufficiency is of national importance. Nor can we forget the pressing need to protect agricultural lands that produce renewable sources of energy.

Energy production and land protection will impose rigorous demands on us, demands that will become increasingly urgent as agriculture is asked to produce still more food and fiber in the future. To meet these needs, work in areas such as disease control, genetic improvement, and plant and animal efficiency will have to be intensified.

How should the Illinois Agricultural Experiment Station respond to such clear-cut needs that come at a time when the research dollar is shrinking? The answer, we believe, lies in developing a comprehensive frame of reference suitable for all research efforts, both basic and applied. — *R. G. Cragle*

Animal Toxicology Hotline



These beef cattle died after eating feed accidentally mixed with corn rootworm insecticide.

WILLIAM B. BUCK

We live in an age of intensive agricultural and industrial production. To sustain high levels of productivity, millions of tons of toxic metals, pesticides, fertilizers, feed constituents, drugs, and chemicals are produced each year. In addition, plants, molds, and bacteria produce many natural toxins.

One of the major questions facing us today is how to assess the quality of the environment and its relation to our health and well-being. If harmful consequences from toxic materials are to be prevented, we must acquire and disseminate new knowledge about their biologic effects as quickly as possible. Through the recently established Veterinary Toxicology Information Service, the College of Veterinary Medicine at the University of Illinois is helping in this effort.

Animals as monitors

For thousands of years people have to some extent relied on animals to monitor the quality of the environment. For example, coal miners used to take caged canaries into coal mines. More vulnerable than humans, the birds were quickly overcome by any odorless, toxic gases that might drift into the mine shaft. With this simple yet effective warning system, miners had time to race to safety when threatened by poisonous gases.

Livestock, pets, and wildlife are our modern-day canaries. Animals breathe the same air we do, drink the same water, and eat from the same food supply. They are also exposed to the same chemicals in the environment, are subject to many of the same disease organisms, and experience similar difficulties from crowding. Close observation of animals is helpful in predicting whether adverse environmental conditions are likely to affect humans, but it is important for preventing the loss of valuable animals as well.

Toxicology hotline

In September, 1978, the College of Veterinary Medicine established a hotline to offer diagnostic assistance with animal poisoning problems. At any time — 24 hours a day — practicing veterinarians, county agricultural Extension advisers, animal owners, and others can obtain information and advice about known or suspected cases of poisoning. This service is provided without charge.

Through an answering service a veterinary toxicologist is on call during regular office hours, evenings, weekends, and holidays. The Veterinary Toxicology Information Service is staffed on a rotating basis by Drs. V. R. Beasley, D. J. Blodgett, R. V. Chalam, L. C. Davis, J. C. Haliburton, and J. R. Wilcke. The hotline telephone number is 217-333-3611.

TOXICOLOGY HOTLINE TELEPHONE

217-333-3611

24 hours a day
Every day of the year

William B. Buck is professor in the Division of Pharmacology and Toxicology, Department of Veterinary Biosciences, College of Veterinary Medicine.

The service also maintains a team ready to investigate suspected or potential poisoning problems anywhere in Illinois. When telephone advice and consultation seem inadequate, the team of investigators, composed of a toxicologist, a pathologist, and a veterinary clinician, is dispatched to assist the attending veterinary practitioner in making a diagnosis and resolving the problem.

The toxicology hotline and its supportive services are maintained cooperatively by the Department of Veterinary Biosciences and the laboratories of Veterinary Diagnostic Medicine at Urbana, and by the Illinois Department of Agriculture Analytical Toxicology Laboratory at Centralia.

First year's results

During the 12-month period from September 1, 1978, to August 31, 1979, the service handled 414 calls about suspected poisonings or requests for information. Slightly more than half of the calls (211) came from within Illinois; the remainder of the inquiries came from 37 other states, two from Canada, and one from Switzerland.

Table 1. — Number of Hotline Calls About Actual or Suspected Poisoning Problems, Sept. 1, 1978, to Aug. 31, 1979

	Number	Percent
Dog	108	36
Cattle (dairy and beef)	75	25
Cat	25	8
Swine	24	8
Horse	23	8
Sheep and goat	10	3
Bird	3	1
Other (mink, rabbit, squirrel, guinea pig, fish)	7	2
Human (exposed to animal drugs)	9	3
Water and feed contamination	16	5
TOTAL	300	..

Almost three-fourths (300) of the inquiries involved animals and even a few humans actually exposed to toxic materials, or animals with clinical signs of poisoning. Only individuals were involved in dog and cat cases, whereas herds or flocks were affected in livestock and poultry cases.

Incidence by species is given in Table 1. The most commonly reported causes of poisoning suspected in five of these species fall into several categories:

Dog (108 incidents):
- *pesticides* (37%), e.g., rodenticides, insecticides, herbicides, wormers
- *drugs and foreign materials* (19%), e.g., antifreeze, ground glass, mink oil, linoleum, household cleaners, skin ointments, drugs prescribed for animal's owner
- *metals* (8%), e.g., lead, arsenic
- *toxic plants and molds* (8%)
- *feed and water contamination* (4%)

Cattle (75 incidents):
- *pesticides* (36%)
- *toxic plants and molds* (13%)
- *feed and water contamination* (9%)
- *metals* (8%)

Cat (25 incidents):
- *pesticides* (28%)
- *drugs and foreign materials* (24%)
- *toxic plants* (12%)

Swine (24 incidents):
- *toxic plants and molds* (33%)
- *feed and water contamination* (29%)
- *pesticides* (21%)
- *metals* (8%)
- *foreign materials* (4%)

Horse (23 incidents):
- *toxic plants and molds* (39%)
- *pesticides* (17%)
- *feed and water contamination* (13%)
- *metals* (9%)

During the same 12-month period the toxicology service conducted twelve field investigations of livestock losses in Illinois. These investigations are summarized by location, species, and type of problem in Table 2.

Table 2. — Illinois Field Investigations as Follow-Up to Hotline Inquiries, Sept. 1, 1978, to Aug. 31, 1979

Location	Problem
Villa Grove	Goat losses: copper deficiency
Sheffield	Beef and dairy cattle losses: near waste chemical disposal area
Martinsville	Beef cattle losses: white snakeroot poisoning
Piper City	Beef feeder losses: atypical interstitial pneumonia
New Lennox	Horse deaths: moldy corn; leucoencephalomalacia
Galesburg	Beef cattle losses: rumen intoxication on corn silage
Wyoming	Dairy cattle problem: contaminated well water and treated seed corn
Greenville	Dairy cattle losses: salt contamination of water near oil wells
Breeze	Dairy herd problem: aldrin-dieldrin contamination
Flannigan	Beef cattle losses: arsenic poisoning
Roseville	Sheep losses: trefoil pasture poisoning
Princeton	Cattle losses: unidentified kidney problems

Program first of its kind

Establishment of this program is apparently the first time that such a service has been attempted for animals. The response from Illinois and elsewhere indicates a need for the program. Moreover, half a dozen human poison control centers in various states have requested permission to refer animal poisoning problems to the toxicology service here at the University of Illinois.

Representatives of the Food and Drug Administration and the U.S. Department of Agriculture have expressed an interest in establishing a nationwide animal poison control service. Such a program could be set up through a communications network among state veterinary diagnostic laboratories.

Along with the emergency information and investigation service, we are developing a file of substances that are toxic to animals, together with toxicity data and recommended antidotes. Eventually this file will contain more than 30,000 entries and will enable us to respond quickly to many different kinds of poisoning episodes.

Repeated Superovulation of Cows

C. N. GRAVES, S. L. SPAHR, and W. F. LUBBADEH

WITH SPERM STORAGE and artificial insemination it is now possible for a bull to sire more than a million offspring. But few cows will give birth to more than ten calves in their lifetime, and most will have only three or four.

By injecting hormones, however, we can superovulate cows. Instead of discharging one ovum or egg cell during each cycle, a cow can be made to discharge many ova at one time. Following superovulation, the embryos from a genetically superior cow can be recovered surgically or nonsurgically and transferred immediately to foster mothers having less desirable characteristics. The embryos can also be frozen for subsequent transfer.

In much of the previous research, cows discharged fewer ova with each successive superovulation. One possible explanation for the decrease is that the cows may have produced antibodies after the first few injections of the hormones that cause superovulation. The injected hormones, which are proteins, could have been inactivated by such antibodies. Another possibility is that when the embryos were recovered surgically, adhesions may have formed or the ovary or oviduct may have been damaged (Fig. 1).

Superovulation procedure

Two groups of hormones are used to induce superovulation in farm animals. One group consists of follicle-stimulating hormone and luteinizing hormone (FSH-LH), which act synergistically to cause follicular growth and ovulation in naturally cycling animals. (A follicle is a sac that encloses the ovum during development.) The other commonly used preparation is a compound isolated from the blood serum of pregnant mares. This compound is often referred to as pregnant mare's serum gonadotropin or PMSG. Although the effects of both preparations are similar, a single injection of PMSG is adequate for superovulation, while FSH-LH must be injected daily or twice daily.

In our studies we tried both hormonal treatments and compared their effects on the number of ova discharged and the number of recovered embryos. Specifically, we wanted to find out which hormonal preparation produced the largest number of ova and whether the cows would become unresponsive to the injected hormones or would build up antibodies.

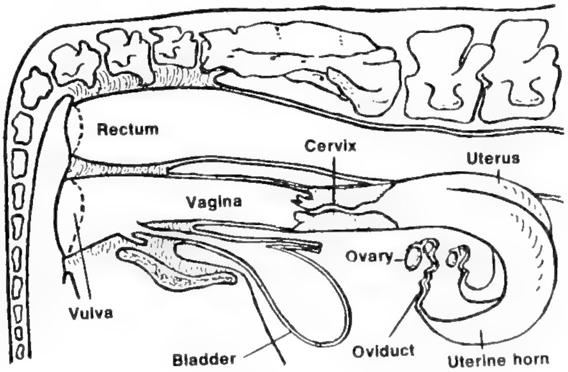
The cows were divided into groups A and B, each group being superovulated a total of five times. Cows in group A were given PMSG three times at 16-day intervals and the fourth time after a 37-day interval that included one complete estrous cycle; the fifth and final treatment was with FSH-LH. Cows in group B were given the FSH-LH first, three times at 16-day intervals, and the fourth time after 37 days; the final treatment was with PMSG. Prostaglandin $F_{2\alpha}$ was administered to both groups at each superovulation to control the time of ovulation.

Removal of embryos

After superovulation the embryos must be removed from the cow's reproductive tract. The actual site from which they are collected depends on their age at the time of removal. For surgical recovery an incision is made in the side of the cow to get to the oviduct, where fertilization and early embryo development occur (Fig. 2). The embryos are then flushed from the oviduct through the incision.

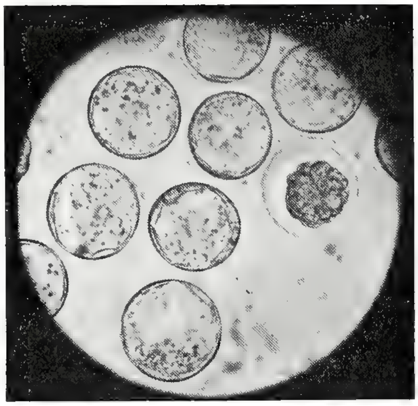
For nonsurgical recovery another five or six days must elapse until the embryos have migrated from the oviduct into the uterus, where implantation and development normally occur. After superovulation, however, a tube is inserted through the vagina and cervix into the uterus to flush the embryos from the uterine horns before implantation. This procedure is similar to that used for artificial insemination, except that instead of semen being deposited, a sterile culture medium is forced into the uterus to flush out the embryos.

The embryos collected nonsurgically from the uterus are in a somewhat more advanced stage of development than those recovered surgically from the oviduct. At the later stage the embryos are less susceptible to injury and thus may be stored more easily at subzero temperatures.



The organs of reproduction of the cow. Embryos removed surgically are collected from the oviduct; those removed nonsurgically are flushed from the uterine horn. (Fig. 1)

C. N. Graves and S. L. Spahr are associate professors and W. F. Lubbadeh is a former graduate research assistant in the Department of Dairy Science.



Embryos flushed from the reproductive tract 8 days after fertilization. (Fig. 2)

Positive results

We had four main objectives in these studies: (1) to compare the effects of FSH-LH with PMSG, (2) to establish the time required between sequential treatments for the best results, (3) to determine if the response decreases with repeated superovulations, and (4) if so, whether the decrease is due to a build-up of antibodies against the injected hormone.

Of the two hormonal preparations used in these studies, FSH-LH was significantly more effective than PMSG (Table 1). Although four successive superovulations were carried out with the same regimen, the time span from the first to the fourth varied from 4 to 12 months among cows. During this time each cow was given a total of either 16 injections of FSH and 20 of LH or 4 injections of PMSG. Group B cows, those given 4 treatments with PMSG, discharged considerably fewer ova during the second and third periods than did group A cows. Variability among cows in each group was considerable.

The time interval required between consecutive superovulatory treatments clearly has a bearing on the response. Between the first and second periods, and also between the second and third, the interval was only 16 days. This short interval apparently accounts for the decreased response in the period that followed (Table 1). When one entire estrous cycle was allowed before the next superovulation, as was the case before the third and fourth periods, the response was comparable to that in the first period. Therefore, cows can probably be superovulated on alternate cycles and still produce large numbers of embryos.

In the first hormonal treatment about fifteen ova were released by each cow, although only seven embryos were recovered (Table 1). This disparity seems to average 50 percent in most studies. The reason for the difference is not known, but it may be that not all of the ova are picked up by the oviduct. It may also be that palpating the ovaries through the rectal wall — the usual way of determining the number of ova discharged — leads to an inaccurate count when many ova are involved. In the fourth treatment the numbers of ova released and embryos recovered were similar to those in the first period. This finding shows that, provided treatment intervals are not too close, repeated superovulation causes no decrease in response.

The fact that the response of the cows did not decrease over the 4- to 12-month period, even with so many hormonal injections, seemed to indicate that few if any antibodies were produced. We conducted two types of tests to confirm this finding. In the first of these tests — a single radial immunodiffusion assay — each individual hormone was suspended in agar. Serum from the injected cows was then allowed to diffuse through the suspension. Had any antibodies to the various hormones been present, precipitant lines would have appeared. None were evident, however.

In the second test each hormone was dissolved in serum obtained from a cow injected several times. This serum-hormone mixture was then used to superovulate mice. If antibodies were present in the cow's serum, they would be expected to react with the hormones and thus decrease or eliminate the superovulatory response of the mice. The results showed, however, that the ovulatory response in both the FSH-LH and in the PMSG groups of mice was equal to that of the controls.

The results of both tests, along with the sustained response of the cows to repeated superovulation, seem to indicate that no antibodies were produced against the injected hormones. Therefore the cows may be superovulated many times without decreasing the number of ova discharged.

Table 1. — Responses of Dairy Cows Superovulated Five Successive Times

Period	Group A (No. = 8)[a]	Group B (No. = 8)[b]	Mean (No. = 16)
	Number of ova		
1	17.9	13.9	15.9
2	15.8	1.8	8.8
3	10.9	8.0	9.4
4	21.5	11.4	16.4
5	16.5	19.6	18.0
	Number of recovered embryos		
1	6.8	6.9	6.8
2	2.5	0.5	1.5
3	1.0	2.9	1.9
4	16.5	8.0	12.3
5	2.8	7.1	4.9

[a] Group A: superovulated four successive times with FSH-LH, the first three at 16-day intervals, and the fifth with PMSG.
[b] Group B: superovulated four successive times with PMSG, the first three at 16-day intervals, and the fifth with FSH-LH.

Improved superovulation

At birth, the ovaries of the female of most species contain all of the ova to be ovulated throughout life. A young calf has several hundred thousand egg cells, although the number declines rapidly throughout the life of the animal. A two-year-old heifer has 100,000 to 200,000 ova, but only a very small number will ever be naturally discharged.

Using superovulation procedures, we may now be able to obtain many more embryos than was previously thought possible. Our studies gave no indication of physical damage, health hazard, or reproductive disorders after repeated superovulation and nonsurgical recovery of embryos for five successive times. Studies are underway to determine if these superovulatory treatments have any effect on the subsequent reproductive ability of the cow.

Hens Help Save Energy

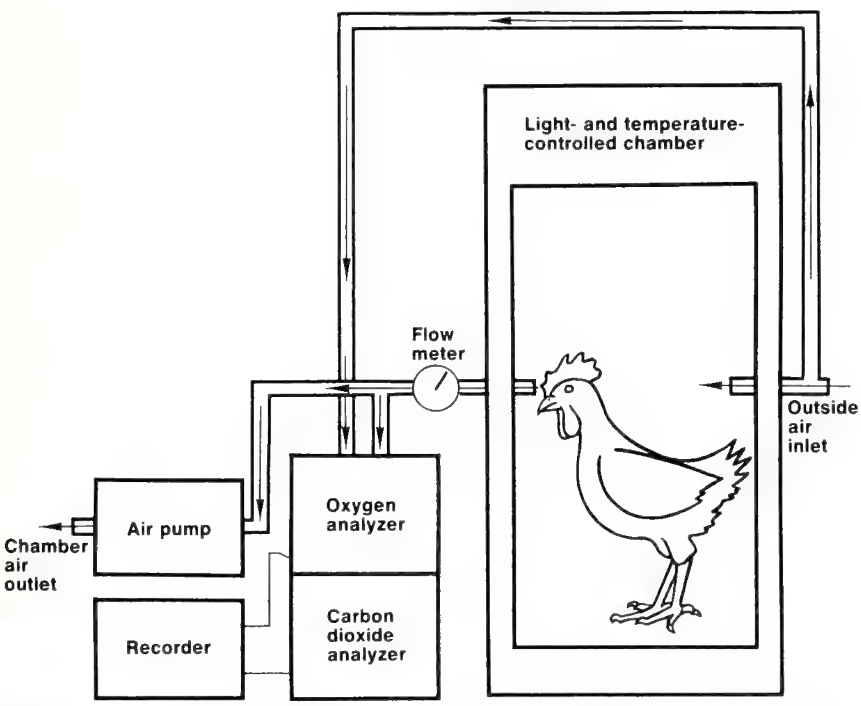
With only five hours of artificial light each day, egg production stays high

T. W. ODOM and P. C. HARRISON

IF LEFT TO THEMSELVES, chickens will not begin laying eggs until spring, when the days get longer. Artificial light can be manipulated, however, so that hens will lay eggs all year. We used to think that hens needed at least 14 hours of light each day to keep production high. But we now know that much shorter periods of light will do the job just as well. Intermittent light of 1 hour on and no more than 5 hours off during a 24-hour period is adequate.

Researchers are not sure why this system works, but physiological processes probably have something to do with it. Hens, like many other living things, have daily or circadian rhythms that recur every 24 hours. The activity of the body and its sensitivity to stimuli such as light fluctuate during this time. Thus a laying hen may be stimulated when its periods of peak sensitivity coincide with the periods that the lights are turned on.

Another possible explanation for the effectiveness of intermittent lighting is that there is a carry-over effect or time lag between stimulation and return to the level before stimulation. Even though the stimulus is of short duration, the effect is long lasting.



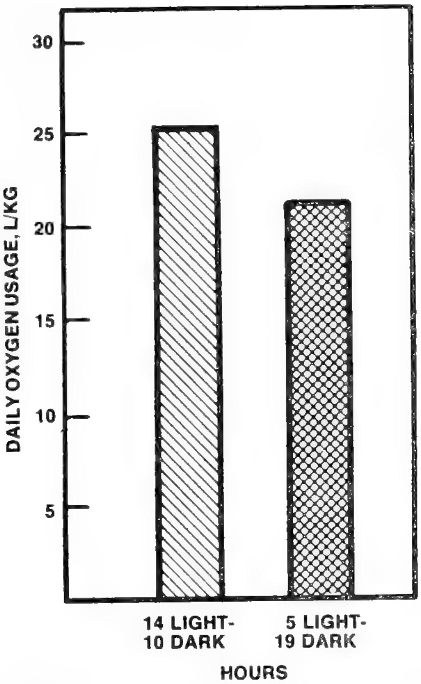
Exhaust air from a laboratory chamber is analyzed to determine the daily oxygen use of hens exposed to conventional and intermittent lighting regimens. (Fig. 1)

Why use intermittent light?

With dwindling fuel supplies and soaring costs, we are searching for ways to conserve energy. One way to save electrical energy and cut costs as well is to use an intermittent lighting system. The reduction for one hen has been estimated by some researchers at about ½ cent per year for each hour the lights are on. For a laying-hen operation with 5,000 birds the annual savings is worth considering.

Feed costs also go down. Because hens do not usually eat when the lights are off, 9 to 12 percent less feed is eaten during the shorter periods of light, according to results reported in other studies. Most of a hen's physical activities during a 24-hour period are associated with eating and drinking. These activities in themselves are energy demanding and thus account for a large part of the daily feed requirement. We reasoned that if we shorten the time when eating and drinking normally occur, then the hens' daily energy requirement should be less.

T. W. Odom is research assistant and P. C. Harrison, professor in the Department of Animal Science.



Total average daily oxygen used by Single Comb White Leghorn hens subjected to two lighting regimens. (Fig. 2)

Table 1. — Production Parameters for Single Comb White Leghorn Hens During 10 Weeks of Oxygen Use Measurement

	14 hr light, 10 hr dark	5 hr light, 19 hr dark
Egg production, %	52.33	44.50
Egg weight, g	66.14	69.63
Egg mass, g/hen/day	34.59	30.99
Energy stored in egg, kcal/hen/day	56.38	50.51
Feed consumption, g/hen/day	99.82	90.30
Production efficiency, g feed/g egg	2.88	2.91
Energy efficiency, kcal ME[a]/kcal egg	5.01	5.05

[a] Metabolizable energy intake.

Using broiler breeder hens, we tested this hypothesis in a preliminary study. The hens were exposed to two different light regimens:

— a conventional 14-hour period of continual light followed by 10 hours of darkness

— an intermittent system of five 1-hour periods of light alternating with four 3¾-hour periods and a fifth 4-hour period of darkness, or a total of 5 hours of light and 19 hours of darkness per day.

The amounts of energy that the two groups of hens required each day was determined by indirect calorimetry, a method for measuring the oxygen used during 24 hours. For the hens on the intermittent regimen there was a 9-percent decrease in daily oxygen use and a corresponding drop in their energy requirements.

Egg production maintained

From broiler breeder hens we went on to test an egg production strain — Single Comb White Leghorns. The purpose of this study was to find out if production could be adequately maintained on the 5 hours of light and 19 hours of darkness. We also wanted to know if the total daily metabolic expenditure would be reduced, as it was in the previous study.

Before the study, 300 Leghorn chicks were hatched and reared with decreasing light periods. At 22 weeks of age 192 birds were randomly assigned to two large, light-controlled chambers in the same building. After a 4-week adjustment period with 14 hours of light and 10 hours of darkness, one of the chambers was changed to the 5 hours of light and 19 hours of darkness regimen. Water and a standard ration for laying hens were available at all times throughout the experiment.

From the thirtieth to the fortieth week of the experiment the total daily oxygen use was measured and then averaged for both light treatments. Fitted with three cages, each chamber was controlled for light and temperature (Fig. 1). Two birds were assigned to a cage for each of the three trials per light treatment.

The exhaust air from the chambers was analyzed over a 24-hour period. For this analysis we used a Beckman F-3 paramagnetic oxygen analyzer corrected to standard temperature and pressure. The temperature was representative of that found in large, light-controlled, commercial operations.

At about 27 weeks of age the hens in both chambers reached sexual maturity or 50 percent of hen-day egg production (egg per bird per day). Between the two groups, peak production differed by only 5 percent (75 percent for the conventional system and 70 percent for the intermittent system). This difference stayed fairly constant throughout the rest of the experiment.

The hens on intermittent lighting had a 15-percent reduction in daily oxygen use (Fig. 2). Their oxygen needs increased very rapidly when the lights were turned on and declined back to the dark-phase level when the lights were turned off. This reduction correlated well with our earlier finding that the hens' activity was limited to the light periods.

Table 1 presents some parameters of Leghorn egg production during the time that oxygen use was measured. Egg mass was estimated by using both egg production and egg weight. Because the hens on intermittent light had a lower production percentage, egg mass was also lower than for the hens on conventional light periods.

The energy stored in each egg was estimated by using a value of 1.63 kilocalories per gram of egg mass. Even though the egg mass and estimated energy per egg were lower in the intermittent experiment, the hens ate less and the eggs were larger than those of hens on the conventional light treatment. Overall, production and feed energy efficiency were therefore the same for the two groups of hens.

Energy savings

Our electrical use of 1,970 kilowatt hours per year represented a savings of $103 for the 5,000-bird operation that we have here at the University of Illinois poultry farm. The savings in feed was even larger: 47 cents per bird per year, or $2,350 for 5,000 birds. From our findings we can safely say that it is possible to keep egg production high while reducing electrical, feed, and metabolic energy consumption with short, intermittent periods of light.

No Yield Plateau At Present For Corn and Soybeans In Illinois

W. M. WALKER, E. R. SWANSON, and S. G. CARMER

In 1979, yields for Illinois's major crops were impressive, averaging 128 bushels per acre for corn and 38 bushels for soybeans. Nationally, corn yields were estimated at 109.2 bushels and soybeans at 31.8 bushels. Several states reported record or near-record production.

Yet only a few years ago reputable scientists and highly respected organizations were forecasting that yields of major crops had just about reached a plateau. We now have good reason to think otherwise in Illinois. A careful analysis of past trends in Illinois's corn and soybean yields can give us a vantage point for speculating about future yields in this state.

The Illinois Crop Reporting Service has published records of state average yields for corn since 1866 and for soybeans since 1919. Fertilizer statistics have been published by the U.S. Department of Agriculture since 1930. Working from these data, we developed regression equations that explain 89 to 97 percent of the observed variation in crop yields and fertilizer use. Time (years) was the independent variable, while the dependent variables were corn and soybean yields and tons of fertilizer nitrogen (N), phosphorus (P_2O_5), and potash (K_2O) used.

Yield variations are of course the result of many factors, among them climate, especially moisture and temperature, and production practices such as plant population, variety selection, and insect, disease, and weed control. Fertilizer use, one of several important management techniques influencing yields, is affected by the economics of production as well as by marketing efforts of dealers and manufacturers.

Corn yields

Corn yields were relatively stable from 1866 to 1937, increasing only 0.12 bushel per acre each year (Fig. 1). Toward the end of this period, 1935 to 1937, Illinois farmers began switching rapidly to hybrids, which were inherently more productive and perhaps more responsive to favorable cropping practices than traditionally used varieties.

Between 1938 and 1955 the changeover to hybrid corn continued. The war years with an emphasis on food production intervened, and, in the latter part of the period, phosphate and potash, along with the nitrogen that had gone into munitions manufacture, were put into crop production. During this time corn yields increased an average of 1.29 bushels per acre each year.

Since 1956, yield increases have been dramatic. From 1956 to 1978 the average annual increase was 2.22 bushels per acre. With an average of 10 to 11 million acres in corn, Illinois farmers lifted production by 22.2 to 24.4 million bushels each year. Many different production practices contributed to this increase: rising fertilizer use was one of them.

Fertilizer use

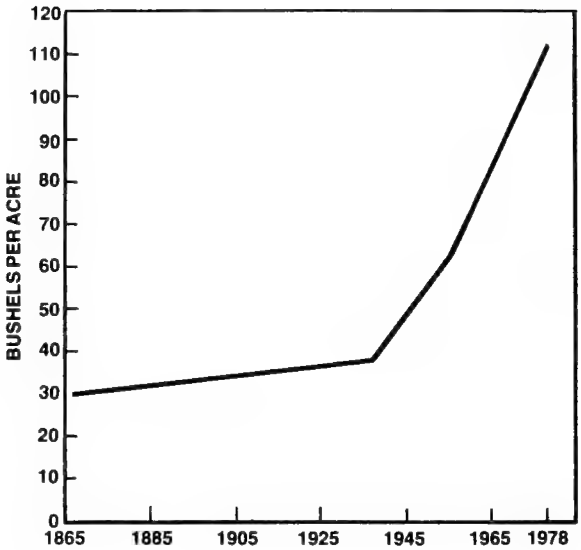
Each year from 1930 until 1943 only about 1,200 tons of nitrogen were sold in Illinois. But from 1944 until 1951 sales increased at an annual rate of 1,686 tons. This period included the last years of World War II and the post-war years, when former munitions factories converted to the manufacture of nitrogen fertilizer. For the next decade nitrogen use rose at an annual rate of more than 17,600 tons, and then 44,060 tons annually between 1961 and 1978. In 1978 nitrogen sales in Illinois totaled 793,000 tons (Fig. 2).

Although nitrogen fertilizer is applied to many crops in Illinois, a high percentage of it goes into corn production. Part of the gain in average corn yields can clearly be attributed to an increase in the use of nitrogen fertilizer.

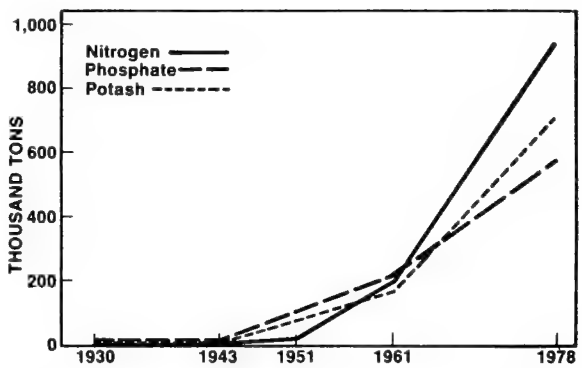
Phosphate use has been similar, but not parallel, to nitrogen in Illinois (Fig. 2). From 1930 to 1943 about 6,850 tons of phosphate fertilizer were sold each year. From 1944 to 1961 the annual increase was about 11,300 tons. This increase almost doubled, to 21,800 tons annually, between 1962 and 1978. Most of the increase occurred in the 1960s, with use in recent years fluctuating between 450,000 and 500,000 tons per year. A high of 587,000 tons was marketed in 1977. Like nitrogen, phosphate fertilizer is used on many different crops, but the 20 million acres of corn and soybeans in Illinois would be expected to receive a large percentage of the phosphate sold.

A similar pattern emerges for potash (Fig. 2). From 1930 to 1943 the average use was 3,486 tons a year. From 1944 to 1961 the annual increase was 9,080 tons, and from 1962 to 1978, 32,000 tons, a rate which was almost four times that of the previous period. A high proportion

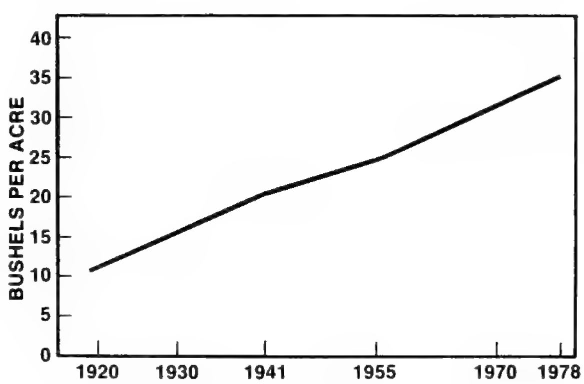
W. M. Walker is professor of biometry and soil fertility; E. R. Swanson is professor of farm management and production economics; and S. G. Carmer is professor of biometry in the Department of Agronomy.



Average Illinois corn yields, which have risen dramatically during the past three decades, show no sign of leveling off at present. (Fig. 1)



Rates for nitrogen, phosphate, and potash application have increased significantly since 1961, with nitrogen having the sharpest increase. (Fig. 2)



Illinois soybean yields have increased an average of almost half a bushel per acre annually during the past decade. (Fig. 3)

of potash fertilizer is applied to corn and soybean fields.

The upsurge in fertilizer sales during the 1960s and 1970s can be explained in several ways. Through public and private education programs, producers were receiving favorable information about fertilizer use. Unlike their forebearers, the recent generation of producers is better educated and more open to adopting new practices. Research, both agronomic and economic, assured producers that by using fertilizers they could expect improvement in crop yields and consequently in farm income. Plant breeders were also at work during these two decades, developing crop varieties that were more responsive than the old ones to fertilizers.

Soybean yields

Soybean yields present a somewhat different picture. Although yield increases have been steady over time, they have not been nearly so dramatic as those for corn. Even so, the yield increases have been significant, probably because producers have adopted a combination of beneficial management practices suggested by research findings.

From 1919 until 1940, while farmers and researchers were learning the science and art of producing soybeans, acreage increased from about 3,000 to 3 million acres, and yields rose by an annual average of 0.49 bushel per acre (Fig. 3). From 1941 to 1956 the yield increase slowed down to about 0.22 bushel, but total acreage in soybean production reached 4.65 million. Yield increases picked up again between 1957 and 1978, averaging 0.44 bushel per acre each year, and acreage almost doubled, to 9.19 million acres.

Upward trend

Both corn and soybean yields in Illinois are still trending upward. Nothing in this study indicates that there is a leveling off, contrary to predictions a few years ago. As long as producers continue to adopt favorable production practices, which stem largely from research efforts, then yields should continue to rise for some time. Only if the research base for developing future management practices declines will there be a leveling off of corn and soybean yields.

At present we have an unused reservoir of production information that producers can tap. If this reservoir decreases and is not replenished, then crop yields could reach a plateau fairly soon. Whether new production information continues to be available to producers will depend largely on improvements in research funding and the creativity of researchers.

Funk Awards Presented

FIVE College of Agriculture staff members were cited for "outstanding performance and high achievement" in the tenth annual Paul A. Funk Recognition Program, held in Urbana on March 7. Each citation was accompanied by a cash award. Funds for this program are provided by the Paul A. Funk Foundation of Bloomington.

The award winners are listed below, along with brief summaries of their major achievements.

Aldon Homan Jensen

Dr. Jensen has been a leader in revolutionizing the hog industry. Largely because of his research on confinement housing, swine production has developed from a seasonal process into a continuous one and has become a major industry rather than a subsidiary to crop production.

He is regarded as the originator of slotted floor systems in this country. The space guidelines that he devised for swine in confinement are used throughout the United States and in many other countries today.

Among his other research projects, he has studied the interactions between thermal environment and nutrient requirements of swine; feed handling and processing systems; and raised floors for young pigs.

An effective teacher, he has shared many of his findings with students, for whom there is great employer demand. In 1972 he received the first American Society of Animal Science Management Award, an indication of the high esteem in which he is held by his peers.

Benjamin Arthur Rasmusen

Dr. Rasmusen is recognized both here and abroad for his research on animal blood groups and biochemical genetics.

In sheep, he found that the genes which control variation among red blood cell antigens in the M system also regulate variation in levels of blood cell potassium. In swine, he discovered a relationship between red cell antigens and the porcine stress syndrome. Both discoveries are important breakthroughs in understanding the significance of blood group differences in animal welfare.

Dr. Rasmusen is president of the International Society for Animal Blood Group Research, and has been twice elected to the editorial board of the journal, *Animal Blood Groups and Biochemical Genetics*.

The new courses that he developed in human evolution and animal genetics have greatly strengthened the quality of instruction in these areas at the University of Illinois.

Gene Clere Shove

Dr. Shove is perhaps best known for his research on low temperature drying. His investigations of this method in the late 1960s and early 1970s established it as a practical, economical way to dry corn and other grains. More recently he has directed a very active research program on the use of solar energy to reduce dependence on fossil fuels for grain and hay drying.

Through his writings and his presentations at meetings throughout the state he has kept the Illinois agricultural community informed of his research results. Since 1968 he has been the principal organizer of an annual Grain Conditioning Conference, which draws people from many states and Canada.

One of his chief contributions to educational programs at the University of Illinois has been the development of a course on grain conditioning and drying. Dr. Shove has also delivered invited lectures in Canada, Yugoslavia, and Italy on the uses of solar energy in agriculture.

Marvin Phillip Steinberg

Dr. Steinberg is widely esteemed for his invaluable contributions to food engineering and processing. For the past ten years he has concentrated on soybean processing to help fill a worldwide need for more protein in human diets. He has developed a wide variety of products, including a soybean beverage base that can be used to prepare analogues of milk, ice cream, yogurt, snack dips, and margarine.

He has also been investigating the role of individual constituents in regulating water activity in foods. One aim of his studies is to preserve foods at intermediate water levels. When perfected, this process will be much more economical than current preservation methods and will represent a major breakthrough in food processing.

Dr. Steinberg has for many years contributed generously of his time and talent to extension activities and has been in great demand for his excellent speeches and demonstrations.

Frank Jay Stevenson

An international authority on soil organic matter, Dr. Stevenson has studied nitrogen compounds in soils and sediments, the structural chemistry of soil organic colloids, and the reactions of micronutrients with organic matter.

Chemical methods that he developed have been adopted for analyses of organics in sediments, including those from the ocean floor. Another major contribution was his demonstration that ammonium is present in igneous and sedimentary rocks, silicate minerals, and clays. His research has had important practical significance for soil management and crop production.

Dr. Stevenson was a Fulbright Research Scholar in Australia in 1961-62 and has held five National Science Foundation Grants. His participation in numerous symposia and conferences on soil science and organic geochemistry has both enhanced his reputation and advanced the state of knowledge in his field.

Hardwood Utilization

POO CHOW

FEW BUILDERS and furniture manufacturers need to be reminded that raw materials are becoming harder to get. Consumers feel the shortage, too, because many hardwood products are simply too expensive for the average pocketbook. The use of fiberboard, usually made of softwood residues and mill wastes, is one way to cut costs.

Hardwood residue panelboard

As the wood shortage becomes more acute, however, we need to take advantage of the little used residues and bark from dense hardwoods. In our laboratory here in the Department of Forestry we tested northern red oak waste materials and found that they can be converted to a highly acceptable panelboard.

Red oak sawdust and bark were collected from an Illinois lumber mill and then defiberized in a commercial, steam-pressurized attrition mill, a machine with toothed metal disks that rotate in opposite directions. Before being fed into this machine, the bark had to be reduced to a suitable size and form in a hammer mill. Moisture content for both materials was 8 to 10 percent at the time of refinement.

Produced by a dry process, the twelve boards used in this experiment measured 17 x 19 x ½ inches after trimming. The binder was a commercial phenol-formaldehyde adhesive, to which a 1-percent wax emulsion was added. Conventional techniques were used for forming and hot-pressing the boards for 9 minutes at 340°F to a panel density of 45 pounds per cubic foot. Three adhesive contents were tested: 4, 6.5, and 9 percent of the oven-dry weight of the furnish (sawdust and bark).

Tests were conducted to determine maximum bending strength, stiffness, tensile strength perpendicular to face (internal bond), tensile strength parallel to the length of the test specimen, face-screw holding, and the linear expansion that develops when the relative humidity is increased from 50 to 90 percent at 70°F. The procedures followed were those specified by the American Society for Testing and Materials, except that specimens were conditioned before testing at 50 rather than 65 percent relative humidity.

The edges of the boards were tight and the density was uniform throughout the wood and the bark fibers. The type of fiber and the amount of adhesive, along with their interaction, influenced the strength tests and linear expansion values (Table 1).

The wood fiber specimens proved stronger and expanded less than the bark at all three adhesive levels. The difference in performance between the two may be due to the fact that the wood particles consist of interlocking strands, whereas the bark particles do not interlock. For this reason, at 4-percent resin content the bark fibers had a poor showing in tensile strength parallel to face and in bending strength, two properties that depend on the strength of cellulose molecules in the fibers.

Increases in adhesive content of the wood fiberboard produced stiffer panels with better fiber-to-fiber bonding strength, higher screw-holding values at the panel surface, and lower average linear expansion values. These same properties also improved, but to a lesser extent, in the bark fiberboard when the adhesive content was increased from 6.5 to 9 percent.

Table 1. — Effects of Adhesive Content on Fiberboard Made From Red Oak Bark and Sawdust Pressed to a Density of 45 lb/cu ft

Pressure-refined furnish	Adhesive content, %	Bending strength, psi	Stiffness, million psi	Internal bond, psi	Tensile strength, psi	Face-screw holding, lb	Linear expansion, 50-90% relative humidity
Bark fibers	4.0	1,100	.26	50	470	160	.50
	6.5	1,300	.29	70	530	170	.46
	9.0	1,400	.30	92	640	220	.41
Wood fibers (coarse sawdust)	4.0	1,800	.35	45	740	250	.60
	6.5	2,400	.41	80	1,010	290	.53
	9.0	2,800	.48	114	1,150	340	.51
Minimum requirement for commercial particleboard[a]	..	1,800	.25	65	1,000[b]	225	.35

[a] U.S. Commercial Standard 236-66, type 2, class 1, medium density phenolic-bonded particleboard.
[b] According to U.S. Voluntary Products Standard PS 58-73 for medium density hardboard.

Table 2. — Values for ¾-Inch Composite Panels Veneered With Red Oak[a]

Shelling ratio	Actual density, lb/cu ft[b]		Moisture content, %	Stiffness, million psi	Maximum bending strength, psi
	Core	Composite			
.333	59.3	52.8	6.4	1.2	9,400
.262	55.4	52.7	6.6	1.2	8,600
.167	52.3	53.7	6.8	0.8	6,000
.094	55.0	54.4	6.5	0.7	4,800
.000	57.4	57.4	5.8	0.5	3,000

[a] Each value is the average for two tests.
[b] Actual density is based on air-dry weight and air-dry volume; nominal density of core is 55 lb/cu ft.

Poo Chow is associate professor of wood science in the Department of Forestry.

Panels made from red oak sawdust with 6.5 and 9 percent resin levels met or exceeded the minimum average bending strength and stiffness values required for exterior commercial particleboard in medium density class 1 (type 2-B-1). Panels made from both kinds of residue exceeded the minimum internal bond requirement for medium density hardboard as specified in Commercial Standard PS 58-73.

Veneered panelboard

Consumers often wonder if veneered particleboard paneling is as strong as solid wood paneling. In previous studies of strength and other properties related to particleboard panels overlayed with walnut veneer, it was found that the bending stress values were about the same for both paneling and solid walnut lumber when the shelling ratio was 0.5. Shelling ratio is the ratio of the face-veneer thickness to the total thickness of the veneered panel.

Although these earlier tests were conducted on specimens that were only 2 x 20 inches, the results indicated that an improved hardwood composite panel might be developed by laminating hardwood veneers of higher density onto composition board, also of a higher density. The main purpose of the present study was to use larger panels for determining the relative effects of the shelling ratio on bending strength and stiffness.

Stiffness is a measure of a material's resistance to being deformed and is of prime consideration in designing most structures. Bending strength is a measure of the ultimate flexural or beam strength of a material. This property is used to derive allowable stresses for the load-carrying parts of a structure.

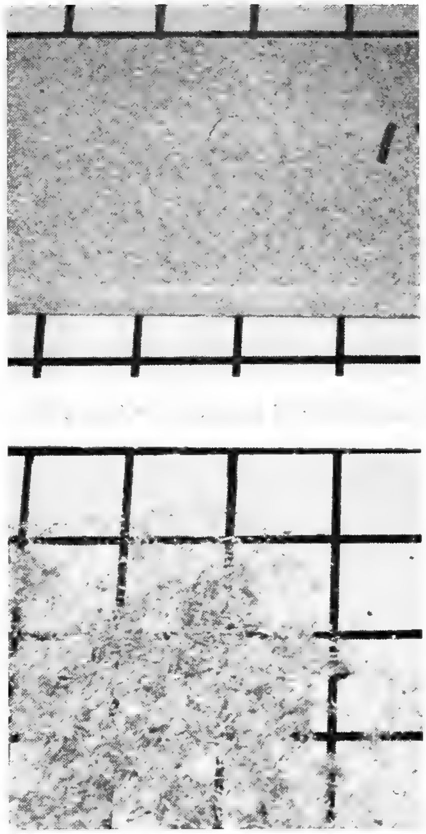
The panels used in this study measured 12 x 39 inches after trimming. The total thickness of each panel was about ¾ inch, including the glue line and veneer, which was red oak rather than walnut as in the previous studies. The veneers used were of four thicknesses: ⅛, 1/10, 1/16, and 1/28 inch. Each was glued with the grain running lengthwise to hardboard cores having a density of 55 pounds per cubic foot. Melamine-urea adhesive was applied to the cores at a spread rate of 40 to 50 pounds per 1,000 square feet. The composite panels were then hot-pressed at 265°F and 160 pounds per square inch (psi) for 5 to 7¼ minutes, depending on the shelling ratio. After pressing, the panels were trimmed and conditioned at 50 percent relative humidity and 75°F to a constant weight.

Nonveneered hardboard used as controls and composite specimens were simply supported over a 36-inch span, giving a span-to-depth ratio of 48:1. Two specimens of each type of panel were tested.

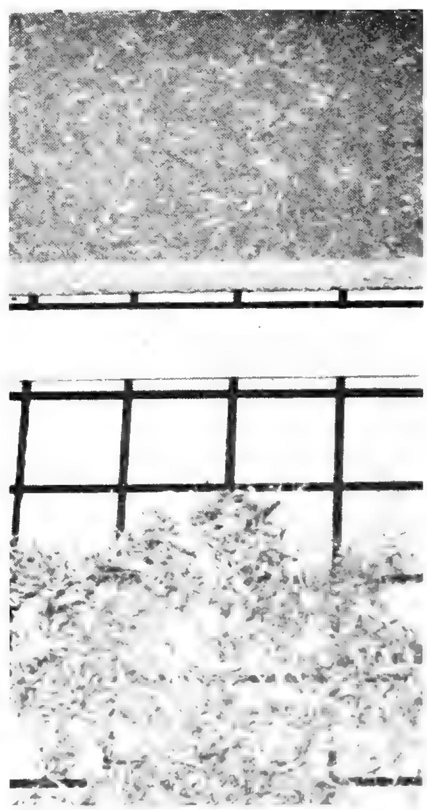
Average densities for the hardboard core and for the composite panels, along with the moisture content, stiffness, and bending strength, are shown in Table 2. The shelling ratio given for each of the four veneer thicknesses had a significant effect on panel stiffness and bending strength. Without veneer the siffness of the hardboard was 0.5 million psi; however, the stiffness more than doubled, to 1.2 million psi, when a piece of veneer ⅛ inch thick was glued to each side of the hardboard.

The load that a panel such as a bookshelf will support depends on the bending strength of the panel. Without veneer the bending strength was 3,000 psi. With the addition of ⅛-inch veneer (shelling ratio, 0.333), the panel was three times stronger, averaging 9,400 psi.

The application of 1/28 inch of red oak veneer (shelling ratio, 0.094) to hardboard increased the bending strength and stiffness more than 50 percent above that of the plain hardboard. An increase in shelling ratio from 0.167 to 0.262 further improved these properties. But the increase from 0.262 to 0.333 did not improve bending strength and stiffness significantly. The effect of shelling ratio on bending strength increased at a more linear rate than did the effect of shelling ratio on stiffness.



Panelboards made from red oak sawdust (top) and red oak bark (bottom).



Flow Capacity of Deflected Plastic Drainage Tubing

P. N. WALKER and C. L. ARMSTRONG

SUBSURFACE DRAINS for getting rid of excess water are vital to agriculture in much of Illinois. Traditionally these drainage systems have been constructed of clay and concrete tiles. In recent years, however, corrugated plastic tubing has become widespread.

How well this tubing serves the purpose may depend on the extent to which it is deflected or compressed before, during, or after installation. Before installation, improper handling or loads imposed by animals or machinery may cause deflection. During installation, deflection is sometimes caused by stones or large clods of soil remaining next to the tubing or falling on it. After installation, soil and machinery loads may cause problems.

Flexible tubing gets most of its structural strength by bending to gain sidewall support. When buried tubing is subjected to loads from above, its vertical dimension decreases while the horizontal increases. As a result, the tubing pushes against the surrounding soil until enough sidewall pressure is exerted to resist further deflection.

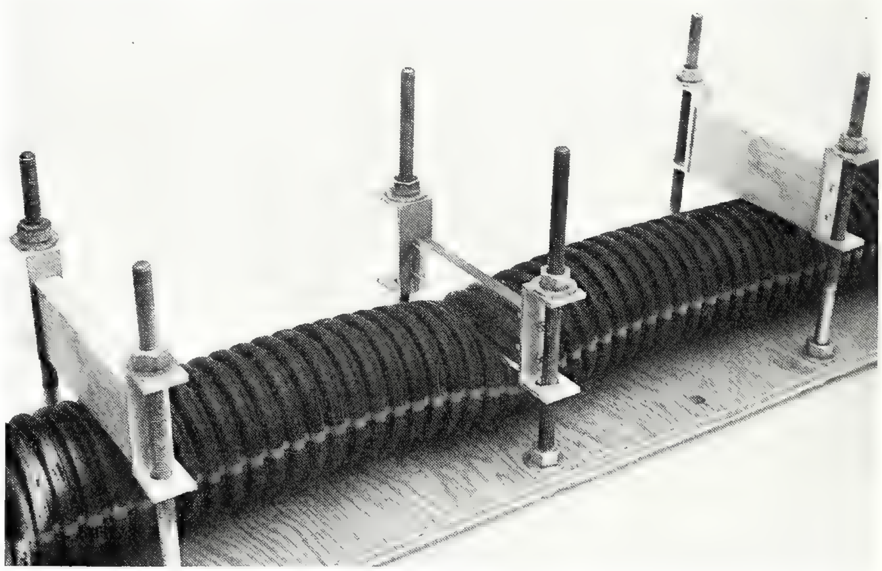
The purpose of drain tubing is to convey water. One type of failure occurs when the tubing is deflected to the point where it can no longer do so at the required flow rate. Our research was designed to compare the effects of various idealized deflections on the flow capacity. The information from the study is useful for evaluating failure in specific cases.

Laboratory testing

A measure of the ability of deflected tubing to convey water is the flow capacity ratio, which is the ratio of the capacity of tubing with deflected sections to the capacity of the same tubing without deflections.

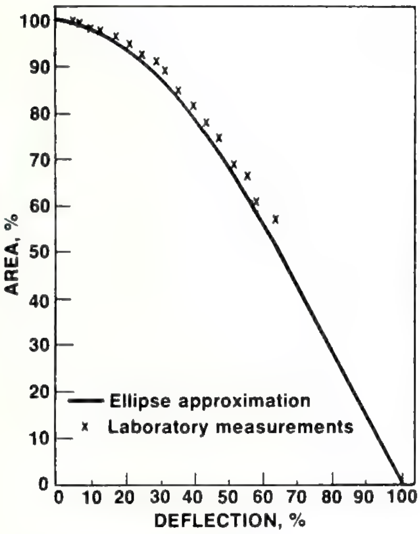
We used traditional hydraulic relationships to develop an equation for predicting this ratio for uniformly deflected tubing and tubing with one deflected section or several identically deflected ones. Using these relationships and assuming that the cross-sectional shape of deflected tubing is elliptical, we can see that for uniformly deflected tubing the flow capacity ratio is a function of the deflection state alone, not of tubing diameter. On the other hand, tubing diameter is important for determining the flow capacity ratio associated with intermittent deflections.

The equation was checked in the laboratory by letting water flow through several lengths of tubing and then measuring the pressure loss associated with the deflected part. To continuously deflect the tubing we compressed it between a set of parallel plates. To produce point deflections we used the device shown in Figure 1. Piezometer taps and manometers were placed at each end of the sections to measure pressure loss.

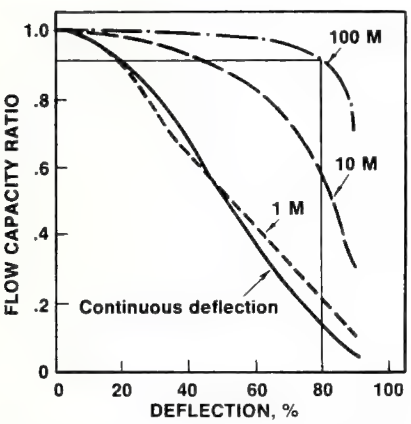


This device for creating point deflections of plastic drain tubing was used to simulate compression caused by stones, animals, machinery, and other types of loads. (Fig. 1)

P. N. Walker is assistant professor and C. L. Armstrong, former graduate assistant in the Department of Agricultural Engineering.



Decreased cross-sectional area of tubing resulting from deflections. (Fig. 2)



Flow capacity ratios for continuous and point deflections at spacings of 1, 10, and 100 meters along 100-mm tubing. (Fig. 3)

Decreased flow capacity

The cross-sectional area decreases with deflection, but the relationship is not linear (Fig. 2). For example, a deflection of about 27 percent is required to reduce the cross-sectional area by 10 percent. This area can be accurately predicted for laboratory deflections by using an ellipse approximation.

Deflection also causes a decrease in the flow capacity ratio (Fig. 3). For uniformly (continuously) compressed tubing, a deflection of about 22 percent is needed to reduce the ratio by 10 percent. Tubing continuously deflected 15 percent retains 95 percent of its original flow capacity, but only 55 percent of its capacity at 50-percent deflection. A 5-percent decrease in capacity would not be serious for most installations. Therefore, tubing deflections of 15 percent or less would not usually constitute hydraulic failure.

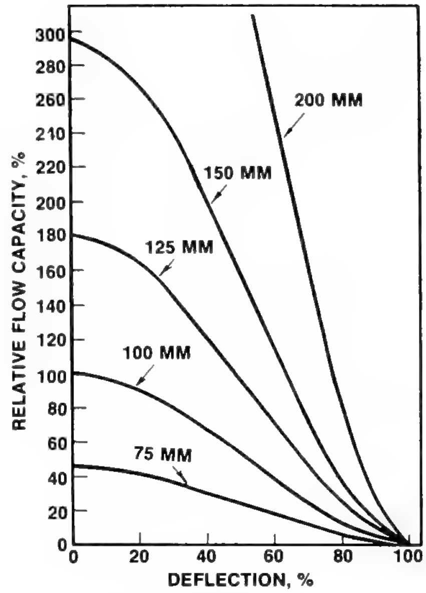
Figure 3 also shows the decrease in flow caused by point deflections at various spacings along the entire length of a nominal 100-millimeter (mm) tube. The curves show that large deflections at close spacings decrease the flow. However, flow is not greatly reduced by large deflections at wide spacings. For example, a 100-mm tubing with 80 percent deflections every 100 meters would retain 92 percent of its flow capacity. Continuously deflected tubing and tubing with point deflections of that same magnitude spaced every meter have about the same capacity.

We then calculated the capacity for continuously deflected tubing having different diameters (Fig. 4). The capacities shown are relative to undeflected tubing with a nominal inside diameter of 100 mm and an arbitrary capacity of 100. The five tubing sizes used here are those commonly available commercially within the range shown. When deflected 50 percent, tubing of a given diameter has about the same capacity as undeflected tubing of the next smaller size. Hydraulic failure can therefore be considered to have occurred before 50 percent deflection; had a smaller capacity been acceptable, smaller tubing would have been installed initially.

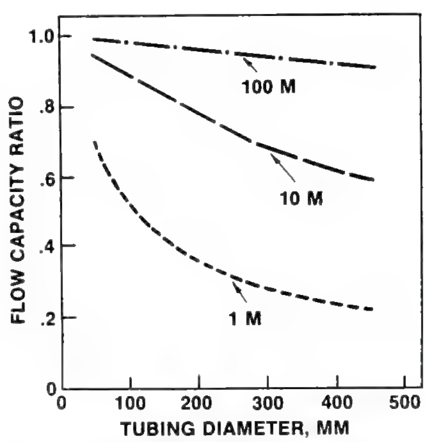
Figure 5 shows the relationship between flow capacity ratio and tubing diameter for point deflections of 50 percent at various spacings. In this case, the flow capacity ratio is smaller for tubing with a larger diameter, unlike tubing with a continuous deflection where diameter is not a factor.

Hydraulic failure

This study has shown that when tubing is continuously deflected, the point of hydraulic failure occurs be-



Capacity of deflected tubing as percent of capacity of undeflected 100-mm tubing. (Fig. 4)



Flow capacity ratios for tubing having different inside diameters with 50-percent point deflections at three spacings of 1, 10, and 100 meters. (Fig. 5)

tween 15 and 50 percent deflection. The exact point of failure within that range will depend on each particular installation. However, deflections of more than 50 percent may be acceptable if they are short and widely spaced. Keep in mind that we considered only flow capacity failure here. Other types, such as structural failure, may be more important in many circumstances, and must also be taken into consideration. Research is continuing so that we can better define these other types.

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FARM BUSINESS TRENDS

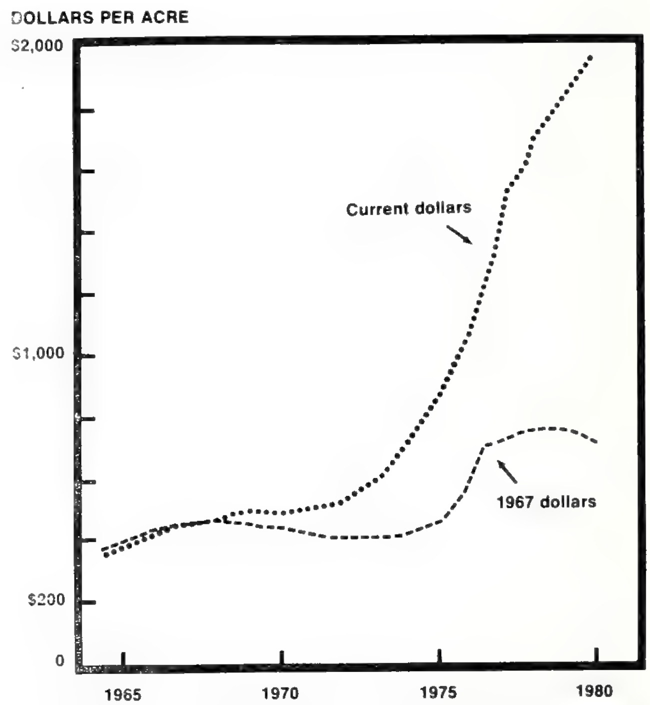
Over the past year the growth rate of prices for Illinois farm real estate has slowed. From a 13-percent increase between February, 1978, and January, 1979, the rate dropped to 10 percent for November, 1978, through October, 1979. The rise was only 8 percent for the twelve months ending January, 1980, as the index of 476 shows:

	Index of Illinois farmland values	Index of prices paid by U.S. farmers for commodities, taxes, interest, wage rates
1980, Feb.	476	271
1979, Feb.	441	238
1977, Feb.	353	200
1975, Mar.	209	185
1973, Mar.	129	145
1971, Mar.	108	120
1969, Mar.	109	109
1967, Mar.	100	100

Actual reductions in prices paid per acre are expected for the immediate future, largely in response to escalating interest rates and rapidly rising farm operating costs. Rising costs, already evident for 1980, will reduce net cash farm incomes, leaving less money for amortization payments. Higher interest rates will increase the cash outflow required to finance the borrowed part of farm real estate purchases.

Farmland price movements are not uniform throughout the state. Prices are currently weakest in the cash grain-producing areas, but are firm or rising in dairy- and cattle-producing areas. Although hog producers are not very bullish at this time, expected supply adjustments are likely to restore their purchasing power.

On February 1 of this year, an average acre of Illinois farm real estate was worth $1,930 in current dollars (see graph). But in 1967 dollars, this value was only an estimated $712 per acre. On this constant purchasing-power basis, farmland values have changed little since the end of 1976. The relative stability suggests that further increases in farmland prices may be more or less directly associated with the rate of inflation. We are likely to see some actual price decreases before the market picks up to a longer-term growth rate of perhaps 5 to 7 percent annually. — *Franklin J. Reiss, professor of land economics*



Average values of Illinois farm real estate (land and buildings) based on index of prices farmers paid for commodities, services, interest, taxes, and wage rates. The average compound rate of growth for 1951-1979 in current real estate was 7.99 percent and in prices paid by farmers, 3.97 percent.

Summer, 1980

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

IN THIS ISSUE

A participant in the Chicago Urban Gardening Program proudly displays some of the vegetables he raised (page 3).

COLLEGE OF AGRICULTURE Volume 22, Number 3

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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R. G. Cragle . . . . Director

Sheila R. Wiley . . . . Editor

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APPLICATION OF RESEARCH

RESEARCH RESULTS from the Illinois Agricultural Experiment Station are applied on farms and in farm-related businesses throughout the state. To a smaller degree, research information is also used in neighboring states and in areas of the world far removed from Illinois.

Application of research information is more complicated today than in years past. Over many years, an advanced agricultural production system has been developed, and because of its sophistication, research findings need to be meshed with the system before being widely released to the public. The effort of integrating single findings with the production system is now a major research area in its own right.

We see the study of agricultural systems as "modeling" and "program packaging." Computer capability is needed for both research and for delivery of findings to the farm. Recently, modeling studies have involved problems such as economic returns versus the cost of energy for irrigation, the type of agricultural enterprise best suited to a given area, and formulation of animal rations.

The process of packaging information has now become a facet of research. In general, program packaging has evolved more rapidly than the capacity of most members of the farm community to use the packages. But new methods of information delivery already significantly affect our ability to apply research findings. A comprehensive library of computer farm programs and a widely based delivery system for program-packaged research information must receive more of our attention. — *R. G. Cragle*

Chicago Urban Gardening Program

GREGORY R. STACK

TURNING A VACANT LOT full of bottles, bricks, and trash into something that resembles a garden is not an easy job. Convincing inner-city residents that vegetables will grow in the city is almost as difficult. But the Chicago Urban Gardening Program, guided by the Illinois Cooperative Extension Service, has accomplished what at first seemed impossible.

During the past two years the number of people joining the gardening program has increased markedly. Part of this success is undoubtedly the result of spiraling food costs. The program is also becoming widely recognized as a source of technical assistance.

Participant involvement

With the help of Extension personnel, 621,000 square feet of land in Chicago were planted as backyard or community gardens during the 1979 growing season. This area was a 10-percent increase over the previous year. About 23,000 people were involved in the program, or an increase of 44 percent since 1977.

Throughout the season, Extension advisers and program assistants presented 465 information programs. Contents ranged from garden cultural practices to nutrition and how to cook unfamiliar vegetables. Many gardeners decided to raise vegetables they learned to enjoy through the nutrition and cooking workshops. Programming of this type was done at the neighborhood level.

Spreading information

Other types of programming were broader in scope and reached larger audiences. During the year, the number of radio and television spots increased. Shows aired on two local stations accounted for 367 minutes, most of it during the 5:00 p.m. news hour. All programs served to pass along current garden tips.

Demonstration gardens were an integral part of the Urban Gardening Program. As a teaching tool, they actually showed what a particular variety or planting technique can do for garden production. These 29 gardens, planted in several neighborhoods, often helped convince skeptics that vegetables will grow in the city.

A large garden was also planted and maintained at the Circle Campus of the University of Illinois. This garden was a showcase for garden-plot plans, variety testing, conventional versus intensified gardening techniques, herbs, miniature vegetables, and insect control. Data on yields were collected here to help document the value of home gardens.

Program staff members have been invited to participate in several important city functions, as well as some held in cooperation with the business community. Last year the Department of Consumer Sales, the Chicago Housing Authority, and the Continental Bank each held major garden fairs, for which the staff supplied an educational booth and relayed garden information to the public. Each of these fairs was a one-day function, and together they attracted 30,000 visitors.

About 45,000 copies of newsletters, a significant part of the communication process, were distributed to area gardeners last year. The program also prepares support information such as the "Good Gardening Series," which consists of short, easy-to-read pamphlets on ten major gardening operations.

Gardeners get an early start on a demonstration plot in the Windy City.

Youth involvement

Several youth programs have given urban gardening considerable visibility. During the International Year of the Child in 1979, activities were developed around this theme at a housing project. A group of young people planted and maintained a flower arrangement of the United Nations symbol for the Year of the Child. The urban gardening advisers offered technical assistance, but many local residents and the management also helped. The design, planted along a major highway, received a great deal of attention.

Youth programs are offered to young people 3 to 18 years of age with a wide range of interests and backgrounds. For example, 400 preschool

Gregory R. Stack is Extension adviser in horticulture and special project leader of the Urban Gardening Program.

children studied where vegetables come from and how they taste. Other programs gave 285 young people actual gardening experience and lessons in nutrition and preparation of garden produce.

A more intensive project with ten delinquent youths has taken urban gardening one step farther. The group got involved in clearing a vacant, rubble-strewn lot and in landscaping it from scratch with recycled city materials. Incorporated in the design was a vegetable garden, the produce from which was donated to a local halfway house. The community and the city supported the effort in a big way by making various landscape materials available.

Volunteer help

Volunteers are indispensable to the program's outreach efforts. Last year approximately 60 volunteers, accounting for 1,650 hours of service, helped with local leadership, office work, public relations, youth programs, and demonstration gardens.

Corporate and business support has also been important in program expansion. In spring 1979, more than 7,000 packets of seed were contributed to area gardeners. In addition, a fall tillage program was undertaken, with International Harvester supplying all needed equipment for a month. About 55 businesses and city agencies helped support the program with materials, meeting space, volunteers, media support, land, and much more.

Special projects

Recently a great deal of concern has been expressed about the use of municipal waste as fertilizer for vegetable gardens. The Urban Gardening Program sampled 60 garden sites, some where sludge had been applied, as well as others where it had not.

The initial findings raised the question, "If the soil contains *x* amount of heavy metal from the sludge, how much is actually in the crop?" We then did a citywide follow-up study of 450 soil and plant samples. The data are now being analyzed to see what the correlation is between heavy metal content in the soil and crop type and uptake.

In another noteworthy project, a growing area for plants was set up indoors. The idea evolved when residents of a housing project wanted to find a way of producing seedlings for their large community garden. In years past, residents had relied on vendors, but the variety and quality of the plants had been a continuing source of displeasure. So the residents designed a mini-greenhouse in a basement used for storing old appliances. The design incorporated four fluorescent fixtures and benches to support trays. The experiment proved successful, and two more units have now been established.

Since installation of the units, the dark, dirty basement has been cleaned and painted a bright color. Children's original art work decorates the walls. Bulletin boards for posting gardening information have been hung, and the area has become a meeting room for many activities. The mini-greenhouse has gained both local and national recognition, with other agencies and groups patterning similar projects after this model.

With the mini-greenhouse, gardening can now be a year-round activity that helps save money for seedling transplants. The benches hold about 3,000 seedlings, or 54 flats. Previously, $260 was spent for this number of plants, but now the residents can produce the same number at less than half the cost.

Another project with 24 mentally and physically handicapped persons was very successful. Conducted at the agency's own site, the project used a 1,500-square-foot plot during 24 weekly meetings. Participants learned garden skills, but also had a chance to improve their communication skills. And working together lifted everyone's morale.

Produce from the garden was used in the agency's kitchen, where the handicapped gardeners learned to prepare the vegetables and planned a season's end harvest party. Home economics staff demonstrated simplified canning techniques, and showed the participants how to preserve their vegetables for winter enjoyment.

The bottom line

Estimates of the monetary value of the gardens tended last year can be made on the basis of our observations at the large Circle Campus garden and small neighborhood demonstration plots. The average garden of 200 square feet yields about 0.95 pound of produce per square foot. At this rate, the 621,000 square feet of land yielded 589,950 pounds of produce.

We also averaged the dollar return for various crops raised and compared it with supermarket prices. We arrived a a figure of 65 cents per pound. At this rate, the value of the produce grown was $383,467. The figure is conservative, taking into account various crops and levels of gardening skill and the realization that not all 621,000 square feet were used to the best advantage.

The responses we continue to get in surveys and unsolicited letters probably reflect a very longstanding and subtle interaction between people and plants. Initial results gleaned from a 1979 survey of our gardeners indicate that

- 99% plan to garden next year
- 82% ate more fresh food
- 70% felt they saved money
- 35% ate a greater variety of foods
- 90% felt better about themselves
- 45% felt better about their neighbors
- 47% felt better about their families

Another interesting point is that an average of 4.5 people other than the gardener received produce from the gardens. Thus the program has an important outreach effect and may even act as a catalyst in getting others into gardening.

City gardening is challenging and sometimes a bit forbidding because of the many obstacles not usually faced by suburban gardeners. But we have shown that vegetables can be grown in the city and that the benefits touch many people in positive ways.

Hybrids for a High-Yield Environment

R. J. LAMBERT

SINCE THE 1930s, corn yields have risen an average of 1.3 bushels per acre each year. Now at an all-time high, the outstanding yields in Illinois are no accident. According to some researchers, about 65 percent of that increase has been due to the genetic improvement of hybrids. Improvement of the production environment accounts for the rest of the increase.

If this trend is to continue, interlocking research in hybrid development and high-yield environments must also continue. Hybrid selection along with planting date, soil preparation, pest control, plant population, soil fertility, and water must all be maximized to sustain steadily increasing yields.

As the first step in developing hybrids suitable to a high-production environment, corn breeders must establish germplasm pools for hybrids that have high yield potential, disease resistance, no barren plants, and good stand establishment. Five years ago the Department of Agronomy initiated a project to study high-yield environments and hybrids adapted to them.

Table 1. — Soil Test Results for High-Yield Environment at Urbana, Illinois

	1973[a]	1976	1979
pH	...	...	6.3
P_1 test	120	96	204
K test	400	320	606

[a] Two years before the project was begun.

Production practices

The field for this project is on the Agronomy South Farm here at the university. Soil type is a Flanagan silt loam. Each year half the field is planted to corn and the other half to soybeans in a corn-soybean rotation. Planting dates have varied from April 20 to May 3 the past five years. The corn is planted when soil temperature reaches 50°F.

Fall plowing and spring discing are used to prepare the soil. For weed control, the herbicides Sutan+ and atrazine are applied before emergence with no further row cultivation. We use a row width of 20 inches and a plant density of 32,300 plants per acre to put stress on the corn population for environmental factors such as light, water, and nutrients. But widths of 30 inches and densities from 28,000 to 32,000 also encourage high grain yields.

Unless soil fertility is kept at adequate levels, high yields cannot be obtained. Therefore, with the help of agronomist Gene Oldham, we have sampled and tested the soil and have developed a soil fertility program on the basis of our findings. During the first four years of the project 229 pounds of fertilizer nitrogen (N), 300 pounds of potash (K_2O), and 300 pounds of phosphorus (P_2O_5) were applied per acre each year. In 1979 the levels were increased to 400 pounds N, 350 pounds K_2O, and 350 pounds P_2O_5.

Soil tests for this field indicate that the P_2O_5 level has almost doubled and K_2O increased one and a half times since the beginning of the project (Table 1). The current levels are adequate for good plant growth, and soil pH is in the desired range.

Water is probably the most critical factor in corn production. During the early stage of plant development — from emergence to two weeks before tasseling — the water requirement increases from zero to about 0.15 inch per plant per day. The requirement continues to rise, to a maximum of 0.35 inch per plant per day, during the stage of rapid growth, that is, two weeks before tasseling, through pollination and early kernel development to about five weeks after pollination. Following this stage, the plant's need for water declines.

With the help of C. W. Boast of the Department of Agronomy, we measured soil moisture stress during June, July, and August, 1979. Using soil tensiometers, we took readings at depths of 1, 2, 3, and 4 feet (Fig. 1). As soil moisture tension increases, the ability of soil particles to hold water also increases. Less water is therefore available for the plants.

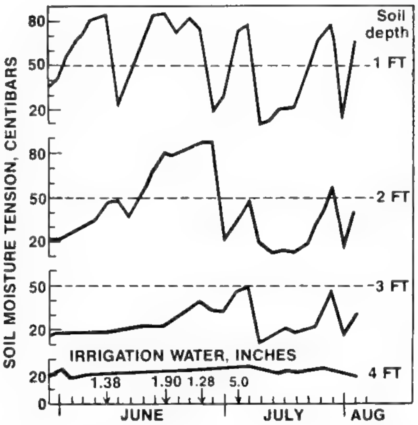
No water stress occurred at 3 and 4 feet during June and July. But a

Table 2. — Grain Yields for Selected Corn Hybrids Grown in High-Yield Environment at Urbana, Illinois

Hybrid	1975	1976	1977	1978	1979	Mean
			bushels per acre			
Mo17 × N28	206	245	153	160	221	197
Mo17 × B73	225	245	176	190	227	213
Mo17 × B84	...	...	...	271	243	257
B73 × Oh545	234	272	195	244	156	220
B73 × Va26	234	245	205	223	227	227
B73 × B77	...	...	...	280	285	283

Table 3. — Grain Yields of Testcrosses Grown in High-Yield Environment at Urbana, Illinois

Pedigree	1978	1979	Mean
		bushels per acre	
RSSSC-17 × B79	235	216	226
RSSSC-64 × B79	221	242	232
RSSSC-98 × B79	221	253	237
RSSSC-200 × B79	235	236	236
RSSSC-145 × B79	225	235	230



Soil tensiometer measurements at Urbana, Illinois, 1979. Irrigation water was applied to relieve stress, indicated by broken line. (Fig. 1)

brief period of stress did occur at 2 feet in June just before the rapid growth stage. Although there were several periods of stress at the 1-foot level, they did not last long and were corrected by irrigation water.

The total water on this field last year from May through August was 25.05 inches, with 15.49 inches as rain and 9.56 inches as supplemental irrigation. As a result of irrigation, the periods of water stress were shortened, thereby contributing to the high grain yields in 1979.

Grain yields

Except in 1977, the yields of selected, single-cross hybrids from 1975 through 1979 were high (Table 2). For certain hybrids the yields did not vary a great deal. For example, for B73 × Va26 they ranged between 205 and 245 bushels per acre. Mo17 × B84 and B73 × B77 had two-year averages that were considerably higher than those of the other hybrids in the project. These superior yields emphasize the importance of selecting the proper genotype for a high-yield environment.

Corn breeders use a testcross procedure to identify superior genotypes before inbreeding to produce inbred lines. To date, the single-cross hybrids and the five testcross hybrids chosen for our project have averaged about the same yields (Tables 2 and 3). Eventually, however, inbreeding in the RSSSC families should produce inbred lines, which will then make hybrids with B79. These hybrids should have yields in excess of 250 bushels per acre.

Two germplasm pools are being used to develop hybrids for a high-yield environment. Estimates of genetic variability in these pools indicate that considerable progress can be made in selecting characters for higher grain yields.

As we gain more experience in controlling various facets of our high-yield environment and make progress in the breeding program, grain yields should continue to rise at the Agronomy South Farm. Even in average environments, however, the hybrids developed here should produce at competitive levels.

R. J. Lambert is professor of plant genetics in the Department of Agronomy.

Firewood Economics

M. F. BOLIN

As the cost of fuel goes up, homeowners are attracted to the idea of heating their homes with firewood. Many people may have encountered the simple logic that all it takes to get started is a stove, a pickup truck, access to free wood, and a chain saw. But if you hope to save on heating bills, the supply of wood must be nearby: that's the key to economizing.

Just how far can homeowners drive before they spend more energy and money for the trip than the wood is worth? The answer lies in some fairly easy but detailed calculations involving such things as the price of conventional fuels, furnace efficiency rating, and British thermal units (Btu's) in a cord of wood. Presented here are sample calculations to help you make realistic decisions about heating with wood.

Before doing the calculations, though, we need to look at seven assumptions developed from an article by Edwin J. Burke ("How Far Should You Go for Wood?" *Western Timberlands.* 6(1):28).

1. The sole purpose of the trip is to pick up firewood, and no dollar value is placed on your time. If the trip is coupled with an outing to buy implements, groceries, or the like, you can go just that much farther for the wood.

2. Many people have to buy a pickup truck and chain saw to get started. The assumption is that it costs 42 cents a mile to own and operate a ¾-ton pickup. If you already own a truck, the operating cost will of course be somewhat less, so again, you can go farther. Chain saws are not included in the computation because most are relatively inexpensive.

3. The ¾-ton truck averages 12 miles a gallon for the trip and holds a third of a standard cord (facecord) when the wood is thrown in and loaded to the top of the truck bed. Partly seasoned wood from standing dead trees or sound fallen ones contains less water and will therefore help improve the mileage.

4. All species of hardwood (broad-leaved) trees have 6,980 Btu's per pound at 20 percent moisture content. Softwood (evergreen) species average somewhat more because of the resins in the wood: 7,560 Btu's per pound at 20 percent moisture content.

5. A standard cord, or three facecords, contains 80 cubic feet of solid wood fiber. Before burning, the wood is seasoned to 20 percent moisture content, which is standard for Illinois.

6. The wood is burned in an air-

tight stove that is 40 percent efficient. Naturally if your stove is more efficient than this, you can travel farther to get wood.

7. Rates charged for conventional fuels vary by location. Also, the efficiency rating of furnaces for the fuels varies with installation and specific use. Computations in this article are based on the following per-unit fuel costs and furnace efficiency ratings:

Natural gas

30¢/therm, 65% = 65,000 Btu/therm

#2 fuel oil

95¢/gal, 65% = 91,000 Btu/gal

Electricity (baseboard)

4¢/kwh, 100% = 3,413 Btu/kwh

Propane

55¢/gal, 65% = 59,000 Btu/gal

Regardless of the type of fuel or wood, the method of calculation is the same. In our example we used natural gas and white oak. See Table 1 for other types of wood. Substitute local figures, the conventional fuel you use, and the type of wood you have access to.

Now do steps 1 through 3 to calculate the Btu's per load (see box). Then, to determine the total round-trip mileage before you use more energy in gasoline than you get from the wood, do step 4. Step 5 will help you to figure the price you are in effect paying for the wood by operating your truck. This step assumes the wood is free, but if you have to pay a nominal fee, simply add it to the cost per load. To determine the maximum round-trip distance you can go for wood before heating with a conventional fuel becomes cheaper, do step 6. Finally, if you think it might be cheaper to have a facecord delivered instead of getting it yourself, do step 7; $16.38 per load is the breakeven point.

The use of firewood will undoubtedly help reduce our dependence on fossil fuels. But homeowners should realize that free wood can be uneconomical if they must travel far to get it.

Step 1:

density (lb/ft^3) × 80 ft^3/cord = lb/cord

47.2 lb/ft^3 × 80 ft^3/cord = 3,776 lb/cord

Step 2:

lb/cord × heat (Btu)/lb of wood = heat/cord

3,776 lb/cord × 6,980 Btu/lb = 26,356,480 Btu/cord

Step 3:

heat/cord × cord/3 pickup loads × .40 (stove efficiency) = heat/load

26,356,480 Btu/cord × cord/3 loads × .40 = 3,514,197 Btu/load

Step 4:

heat/load × 12 mi/gal × gal/130,000 Btu = mi/load

3,514,197 Btu/load × 12 mi/gal × gal/130,000 Btu = 324 mi/load

Step 5:

mi/load × 42¢/mi = cost/load

324 mi/load × 42¢/mi = $136.08/load

Step 6:

heat/load × therm/65,000 Btu × 30¢/therm × mi/42¢ = mi/load

$$\frac{3{,}514{,}197 \text{ Btu}}{\text{load}} \times \frac{\text{therm}}{65{,}000 \text{ Btu}} \times \frac{30¢}{\text{therm}} \times \frac{\text{mile}}{42¢} = 39 \text{ mi/load}$$

Step 7:

mi/load × 42¢/mi = $/load

39 mi/load × 42¢/mi = $16.38/load (breakeven point)

M. F. Bolin is associate Extension forester.

Table 1. — Energy Equivalents for Various Illinois Fuel Woods

Species[a]	Lb/ft^3	Lb/cord	Heat/lb (Btu)	Heat/cord (Btu)	Heat/load (Btu)	Round-trip mileage[b]	Cost[c] ($)	Natural gas (mileage)[d]	Cost[e] ($)
Osage orange	59.9	4,792	6,980	33,448,160	4,459,755	412	173.04	49	20.58
Shagbark hickory	50.9	4,072	6,980	28,422,560	3,789,675	350	147.00	42	17.64
White oak	47.2	3,776	6,980	26,356,480	3,514,197	324	136.08	39	16.38
Hard maple	42.6	3,408	6,980	23,787,840	3,171,712	293	123.06	35	14.70
American elm	35.9	2,872	6,980	20,046,560	2,672,875	247	103.74	29	12.18
Soft maple	34.4	2,752	6,980	19,208,960	2,561,195	236	99.12	28	11.76
Cottonwood	28.4	2,272	6,980	15,858,560	2,114,475	195	81.90	23	9.66

[a] A more complete species list can be obtained from the author, 211 Mumford Hall, University of Illinois, Urbana, Illinois 61801.
[b] A pickup truck consumes 10,833 Btu/mi. Figures in this column represent the total round-trip mileage you can go before you expend more energy in gasoline than is contained in the wood. A chain saw consumes about 21,665 Btu/load, which will further reduce the listed table mileage by an additional 2 miles.
[c] Cost per load; 42¢/mi × round-trip mileage; price you are in effect paying for the wood.
[d] Maximum round-trip mileage you can go and still heat more cheaply with wood than with natural gas.
[e] Cost per load; 42¢/mi × round-trip mileage (column 8); the highest price you can afford to pay for a load delivered to your home and still heat more cheaply with wood.

Iron Nutrition and Infant Feeding

MARY FRANCES PICCIANO

An interviewer explains the nature of the iron nutrition study to a mother. During the study, infants received routine pediatric care and diets typical for their ages.

Iron deficiency, the most widespread nutritional disorder, afflicts 10 to 20 percent of the world's population. Infants are particularly vulnerable because rapid growth during the first year of life accentuates iron needs. Yet 70 to 100 percent of an infant's caloric intake is derived from milk or milk-based foods, which are notoriously low in iron.

Every living cell in the body contains iron in one form or another (Table 1). The bulk of it is found in red blood cells as hemoglobin and in muscles as myoglobin, two compounds that help utilize oxygen. Iron is stored in the liver, spleen, and bone marrow in the form of ferritin and hemosiderin. The transporting form, transferrin, is found in plasma. The rest of bodily iron is associated with cellular enzymes.

Stages of iron deficiency

Iron deficiency occurs in three stages. The first or prelatent stage is characterized by a decrease in ferritin and hemosiderin, the stored forms. The second or latent stage, beginning after iron stores are exhausted, is characterized by a restriction in hemoglobin synthesis and in the amount of circulating iron bound to transferrin in the plasma. Although iron stores have been used up, there is no anemia as yet. In the third and most severe stage, that of overt iron deficiency, anemia results from prolonged restriction of hemoglobin synthesis.

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The degree of deficiency is diagnosed by means of laboratory tests for measuring ferritin and determining the percentage of transferrin saturation. Tests are also run to establish either the level of blood hemoglobin or the volume of red blood cells (hematocrit value), which decreases proportionately as hemoglobin concentration decreases (Table 2).

In 1976 the Committee on Nutrition of the American Academy of Pediatrics recognized the high prevalence of iron deficiency among infants in the United States, and recommended that all infants receive iron supplementation of up to 15 milligrams (mg) per day. At present supplemental iron is available in fortified formulas, infant cereals, and pharmaceutical preparations.

The supplemental iron from fortified foods given to infants early in life is believed to enhance iron stores and to serve as a buffer against iron insufficiency in late infancy and preschool years. Iron deficiency usually develops late in the first year, when most infants are no longer given formula and fortified cereals. Because breast-fed infants do not receive fortified formula, they are theoretically, but not actually, at greater risk of developing iron deficiency than other infants.

Iron adequacy study

We conducted a one-year longitudinal study in our laboratory to determine the extent to which iron adequacy in infants is influenced by the type of milk fed, total iron ingested, dietary source of iron, and bodily iron stored. Ninety-six apparently healthy, full-term infants were enrolled in the study. All were private patients of one pediatrician, thus ensuring uniform health care.

Shortly after giving birth, the mothers were contacted in the hospital. The exact nature of the study was explained to them and their cooperation was sought. If they agreed to participate, the mothers were interviewed in their homes two weeks after delivery. At that time the infants were assigned to one of four groups according to the type of milk they received:

- group I, human milk for at least 3 months
- group II, iron-fortified formula (14 mg per quart) for 4 months
- group III, iron-fortified formula for 12 months
- group IV, the same formula without added iron for 4 months

Giving infants a formula for 4 months is standard pediatric practice. But pediatricians are not in agree-

ment about the necessity of giving iron-fortified formulas to bottle-fed infants to maintain iron sufficiency. Current usage reflects this uncertainty. About half of the infants on formula in this country receive an iron-fortified preparation, and the other half a nonfortified preparation.

Groups II and IV represent infants given these typical formulas. After 4 months the infants in these two groups were weaned to whole cow's milk. In accord with the recommendation of the American Academy of Pediatrics that formula feeding be continued throughout the first year, group III received iron-fortified formula for 12 months.

We performed dietary evaluations at 3, 6, 9, and 12 months of age. At the time of each evaluation, blood samples were taken to assess iron adequacy. Hematological assessment techniques included laboratory values for hemoglobin, hematocrit, amount of iron bound to transferrin, and serum ferritin.

Milk source and iron status

The iron status of these infants was remarkably good. No overt iron deficiency was evident. But subtle differences in iron adequacy were found among groups. At 3 months, elevated values for stored iron were associated not only with the fortified formula, but also with human milk. This finding may at first be surprising, because fortified formula provides at least 20 times more dietary iron than does human milk. But the explanation is rather simple: the iron in human milk is in a form that is readily available for absorption. Other studies have shown that 50 percent of the iron from human milk is absorbed, compared with only 7 percent from fortified formula.

We also found that in late infancy (6 months) the continued consumption of iron-fortified formula or human milk was associated with superior hematological indices of iron sufficiency. Compared with groups II and IV, which were fed formula for only 4 months, groups I and II had elevated values for transferrin-bound iron. At 9 and 12 months, we noted no differences in hematological parameters among groups.

Fortified cereals

Starting at age 2 to 3 months, all four groups were fed infant cereals fortified with 2.3 mg of iron per tablespoon. Use of these cereals was undoubtedly one reason that the iron status of our infants was good.

We should note, however, that when such products are combined with fortified formula, the dietary iron intake is extremely high. Many infants in this study ingested more than 15 mg of iron per day, the maximal level recommended by the American Academy of Pediatrics. At age 6 months, 95 percent of the infants in group III had an iron intake exceeding 15 mg, and in fact 50 percent of the same group had an intake of more than 30 mg. Unnecessary iron supplementation is to be avoided, because some evidence suggests that an excess may increase susceptibility to infection.

We did not observe an absolute relationship between total iron intake and iron adequacy in our infants. Undoubtedly, factors other than total iron in the diet place infants in a precarious state of iron nutrition. High protein intake and the use of too much fresh cow's milk have been implicated. The infants on human milk (group I) or on iron-fortified formula for 12 months (group III) ingested less protein than did the other infants in the study. Moreover, the extensive use of human milk or formula excluded cow's milk from the diet.

Another important factor related to iron adequacy is the relative bioavailability of iron in a dietary source. As noted above, the iron from human milk is more available than the iron from formula. Unfortunately, our information on fortified infant cereals is not so clear: no human studies have been performed to quantify the availability of iron in cereals. Using an animal bioassay, however, we found that availability of the iron in single-grain infant cereals from several manufacturers ranged from 80.5 to 96.1 percent, compared with ferrous sulfate in the diet at the same level. Ferrous sulfate is a highly available form of iron used as a reference standard.

The availability of iron from a mixed diet is difficult to assess. Total amount ingested, as well as the source, influence availability. As the amount increases, the percentage absorbed decreases. It has been found that some iron sources, along with other dietary components, either enhance or depress total absorption. For example, human milk increases and cow's milk decreases the absorption rate of an iron tracer dose.

The relatively large iron intake of bottle-fed infants who receive supplemental iron from two sources concerns some professionals. We are therefore now investigating whether only one source, either fortified cereal or fortified formula, will maintain adequate iron nutrition of bottle-fed infants. Results of this ongoing study should provide much needed data on which to base recommendations for the optimal level and source of supplemental iron for formula-fed infants.

Table 1. — Distribution of Iron in the Body

	Pct. of total
Hemoglobin	60-75
Myoglobin	3
Stored iron	
Ferritin and hemosiderin	0-30
Transport iron	
Transferrin	1
Tissue iron	5-15

Table 2. — Stages of Iron Deficiency and Their Diagnosis

		Stage		
	Normal	Pre-latent	Latent	Overt
Iron stores, mg	200	25	10	1-2
Hemoglobin, g/100 ml	12	12	12	10[a]
Hematocrit, %	35	35	35	30[a]
Iron saturation of transferrin, %	35	35	10[a]	10[a]
Serum ferritin, ng/100 ml	25	10[a]	10[a]	10

[a] These values are usually associated with iron deficiency.

Weather Damage Lowers Quality of Soybean Crop

G. E. URBANSKI, L. S. WEI, and A. I. NELSON

WEATHER-DAMAGED SOYBEANS can spell financial trouble for oil producers or whole-bean processors. If the damage is extensive enough, many thousands of dollars may be at stake. For the past two years weather damage and its effects on the quality of soybeans and oil extracted from them have been a subject of research in our laboratory.

When hard frost prematurely arrests growth of the plants, freeze damage occurs in the beans. Any immature beans on the plant at that time will have a green color. After maturity, field damage is possible. Rain and dampness can partly hydrate the crop if it is not harvested promptly. Under these conditions mold grows rapidly in the beans, turning them a dark brown. Freeze damage is most common in the northern soybean-producing states of Illinois and Minnesota, whereas field damage is a problem in all areas.

Reduced oil quality

Oil is extracted from most of the soybeans produced in the United States. As a preliminary step the beans are crushed. During a later stage of processing, a solvent is added to the prepared beans to extract crude soybean oil. However, before the food industry can use it, the oil must be refined to remove impurities.

The refining process yields what is called neutral soybean oil and undesirable components. The amount of impurities removed is referred to as the neutral oil loss. One major component that adds to this loss is free fatty acid. If it is not removed from crude oil, the end product will taste bitter.

All crude soybean oil contains some free fatty acid. But we have found that the levels are higher in oil from freeze- and field-damaged beans than from an undamaged crop of the same variety (Table 1). Neutral oil loss is therefore greater and the quality lower in oil from damaged beans. Crude oil from damaged beans also contains many color impurities, which contribute to neutral oil loss. For these reasons weather-damaged beans are not recommended for oil extraction.

Increased loss during storage

When soybeans are stored, oil quality continues to decline, as measured by an increase in free fatty acid. Undamaged beans as well as damaged ones are affected. However, the increase occurs at a faster rate in freeze-damaged samples than in those that are undamaged. This trend held true for both Williams and Clark 63, the two varieties we tested (Fig. 1 and 2).

Neutral oil loss runs parallel to these rates as storage time increases. And the longer that damaged versus undamaged beans are stored, the less the oil is worth. To calculate the dollar loss for a typical oil plant that produces 2,400 tank cars of oil per year, we used the industry dockage formula for neutral oil loss and a price of 9.75 cents per pound. Thus an 18-percent increase in neutral oil loss represents an annual dollar loss of $36,000.

Severely freeze-damaged soybeans have higher levels of free fatty acid than do mildly damaged beans (Fig. 2). Thus the degree of damage determines the extent to which free fatty acid will increase and oil quality decrease during storage.

Some of the freeze-damaged beans that we sampled were not noticeably green, except for a very faintly tinged seedcoat. Only upon close examination did the condition be-

Table 1. — Percentage of Fatty Acid in Crude Soybean Oils

Source of crude oil	Free fatty acid, %
Williams	
Field damaged	.19
Freeze damaged	.28
Undamaged	.15
Clark 63	
Field damaged	.23
Freeze damaged	.24
Undamaged	.12

Table 2. — Organoleptic Evaluations of Freeze-Damaged and Undamaged Corsoy Soybeans

	Mean organoleptic scores[a]		
	Color	Flavor	Off-flavor
Not stored			
Freeze damaged	3.8	5.7	4.6
Undamaged	7.9	7.2	7.2
Stored six months			
Freeze damaged	2.9	3.9	3.2
Undamaged	8.6	6.9	6.5

[a] 9 = excellent, 5 = acceptable, 1 = highly unacceptable.

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come apparent. Although visually slight, the damage produced a greater increase in free fatty acid than is normal in undamaged beans.

When outdoor temperatures are suspected of having dropped below freezing, producers should not assume that the crop is undamaged just because the beans are not obviously green. From our experiments it appears that freeze damage, even without significantly affecting the appearance of soybeans, can still cause a reduction in oil quality.

Increases in trypsin inhibitor

Raw soybeans contain trypsin inhibitor, a substance that interferes with the natural digestive enzyme trypsin. Unless inactivated, the inhibitor reduces the digestion of protein in the beans.

In undamaged soybeans, the activity of trypsin inhibitor declines slightly as a result of storing. But when damaged beans, both Williams and Clark 63, are stored longer than six months, the inhibitor begins to increase. Higher levels of trypsin inhibitor present a problem to the processor, because the inhibitor must be inactivated for proper protein digestion.

Quality of whole beans

Although most soybeans are used for oil extraction, some are consumed or processed whole. Our food laboratory has developed many foods from whole soybeans. During this work we have found that organoleptic properties such as texture, color, and flavor are important.

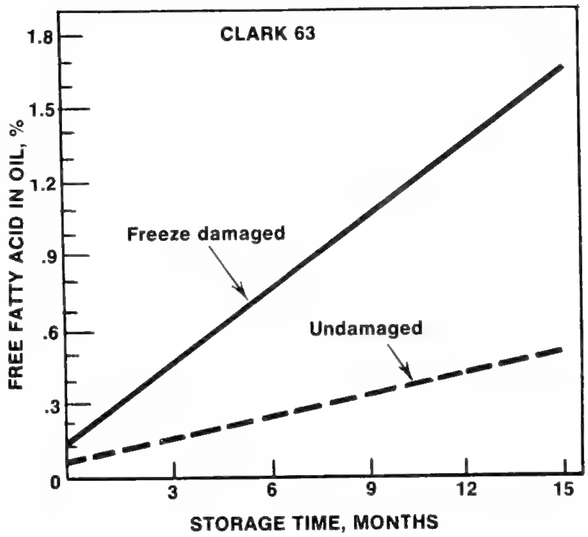
We suspected that damaged beans might present some problems in this respect. We therefore called upon a panel of laboratory personnel experienced in making taste evaluations. Members of the panel were asked to rank damaged and undamaged soybeans of the same variety (Corsoy) soaked overnight in tap water and then blanched for 30 minutes.

Color, flavor, and off-flavor were rated on a scale of 1 to 9, with 9 being excellent, 5 acceptable, and 1 highly unacceptable. A perfect score of 9 would indicate a typical yellow color, pleasing flavor, and no off-flavor. So that the green of freeze-damaged samples would not influence the panelists, the color was masked in the flavor and off-flavor evaluations. The evaluations were made immediately after harvest and again after six months of storage.

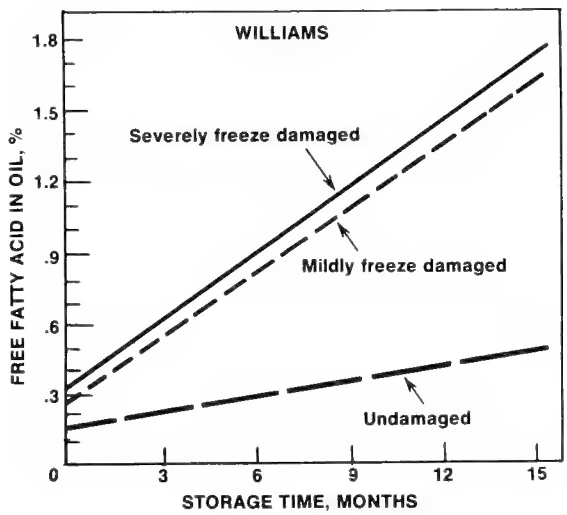
Compared with undamaged soybeans, the green of newly harvested, freeze-damaged beans was disliked, the flavor rated lower, and a greater off-flavor detected (Table 2). Damaged beans were considered still less acceptable after having been stored six months.

Because field-damaged samples were too moldy, the taste panelists were not asked to evaluate them. We strongly recommend that field-damaged beans never be used for direct consumption.

By increasing neutral oil loss, both types of weather damage cause a reduction in the quality of crude soybean oil. The use of weather-damaged beans for oil extraction should therefore be avoided. Field-damaged beans, either whole or as extracted meal, are unsafe because it is quite possible that they may contain toxins produced by mold development. Freeze-damaged beans, although safe for consumption, yield a whole-bean product that has a poor color and a strong off-flavor.



Free fatty acid in oil from freeze-damaged Clark 63 soybeans increased significantly the longer the beans were stored. (Fig. 1)



Free fatty acid in oil from Williams soybeans, even those mildly freeze-damaged, increased at a faster rate than in undamaged beans. (Fig. 2)

Maize Dwarf Mosaic

ELLEN B. REST, MARK A. MIKEL, CLEORA J. D'ARCY, and ASHBY M. RHODES

ILLINOIS GROWERS have been dealing with maize dwarf mosaic for more than fifteen years. This viral disease of sweet corn was first reported on field corn in southern Ohio in 1962. The following two years the disease became severe, causing an average yield loss of 50 percent.

By 1964 maize dwarf mosaic (MDM) had spread into several neighboring states, and was reported for the first time in Alexander County, which is in the southernmost part of Illinois. Subsequently the disease has spread throughout the rest of southern Illinois, where it has remained ever since.

We first found MDM in northern Illinois in 1976. Severe outbreaks during 1977 and 1978 caused significant yield losses. Last year there was no economic loss because MDM arrived late in the growing season. Nevertheless the disease seems established in the northern half of the state.

MDM causes a light green or yellow mottling that starts in the whorl of the youngest leaves. All subsequent growth exhibits disease symptoms: plant stunting, shortened internodes, excessive tillering, and multiple ear shoots. Seed set, especially at the butt end of the ear, is poor.

Means of transmission

MDM is caused by maize dwarf mosaic virus (MDMV), a flexuous, rod-shaped particle about 750 nanometers long and 12 to 15 nanometers wide. (A nanometer is less than 25 millionths of an inch in length.) The infectious part of the virus is its genome of single-stranded RNA surrounded by a protein coat.

In the laboratory and in the greenhouse the virus can be transmitted mechanically by rubbing sap from infected plants onto healthy ones. In the field the virus is transmitted naturally by aphids, which pick it up while probing or feeding on infected plants.

Spread occurs when the aphids move on to other plants to continue feeding. Aphids can pick up the virus in less than one minute and take only another minute to transmit it to healthy plants. When aphids are not feeding, they can retain the virus for nearly six hours.

More than fifteen aphid species reportedly transmit this virus, some species with greater efficiency than others. Existing in two forms, winged and wingless, aphids establish colonies of the wingless form on plants. When there are environmental signals such as seasonal changes or overcrowding in the colony, the winged form develops. These aphids then fly or are blown, sometimes great distances, to areas where they establish new colonies. At present researchers are debating which form, the winged or the wingless, retains MDMV longer.

MDM researchers at the University of Illinois currently are investigating several aspects of the problem: (1) how the disease overwinters and spreads in this state; (2) how viral infection causes physiological changes and related yield loss; and (3) breeding for resistance to MDM in sweet corn.

Overwintering hosts

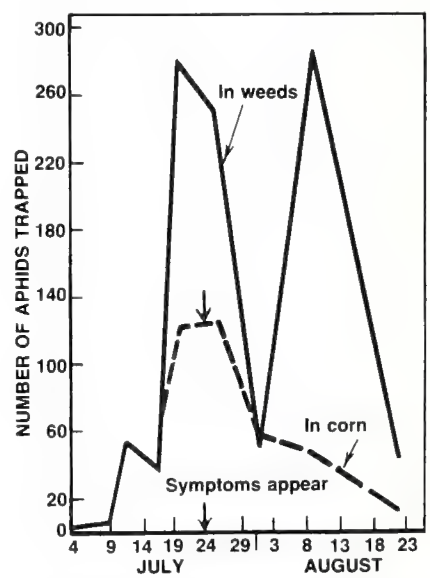
Disease spread is being studied near Rochelle, in northern Illinois, where MDM has been present for the past three years, causing considerable damage in 1977 and 1978. The known overwintering host in the southern United States is Johnsongrass, which does not survive the winter in the northern half of Illinois. A serious problem in its own right, Johnsongrass is not the direct source of local spread each year. A perennial grass similar to Johnsongrass may possibly be a local overwintering host of the virus.

Seed from infected annual grasses or from field or sweet corn may also transmit MDMV from year to year. Another possible explanation for the presence of the virus is that aphids, brought by jet winds, may carry it from infected areas in the southern states.

Aphid identification

Last summer we set up traps at Rochelle to investigate the possibility of aphid involvement in the spread of MDMV. The traps were placed in a corn plot and upwind in a weedy area adjacent to the plot. The number of aphids peaked a few days before disease symptoms first appeared in the sweet corn (Fig. 1). Symptoms of the disease usually appear five or six days after an aphid injects the virus into a plant.

On July 24, 1979, very few plants were infected — less than 1 percent. By mid-August, however, some fields near Rochelle were completely infected with MDM. This very rapid spread indicates that aphids either brought the virus from distant areas



The number of aphids trapped in weeds and in corn peaked several days before the appearance of maize dwarf mosaic symptoms on July 24, 1979. (Fig. 1)

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or spread it from local sources. We have no way to determine the geographic origin of an aphid.

Eleven percent of the aphids trapped last summer, or 153 of 1,455, have been identified in the literature as vectors, but most have never been tested for their ability to carry MDMV in the field. During the summer of 1980 we will try to clarify which species are important in transmitting the virus.

Yield losses

Maize dwarf mosaic virus is less damaging to field corn than to sweet corn because genetic resistance has been bred into field varieties. Unfortunately sweet corn has no resistance as yet. Yield losses result from stunting: plants do not achieve full height, and ears are shorter, smaller in diameter, and underweight.

The goal of one of our studies was to determine at what stage in plant development viral infection results in the greatest yield loss. Corn plants were inoculated with the virus four different times before tasseling. We found that the younger a corn seedling when infected, the greater the yield reduction.

Sweet-corn growers often stagger plantings throughout the spring and early summer. After mid-July, when aphid populations reach their peak, MDM becomes widespread. Growers should therefore be aware that yield reductions due to the disease are apt to be greater for later plantings than for the earlier ones.

Maize dwarf mosaic results in butt blanking, a condition that impairs kernel set at the base of the ear. Butt blanking lowers not only the yield, but also ear quality in fresh market sweet corn. To determine the cause of this condition we undertook a study of pollen vigor in MDMV-infected plants. Silks for kernels at the butt end are longer than those elsewhere on the ear. If less vigorous pollen is unable to grow the full length of the long silks, some kernels would remain undeveloped.

Pollen from seven healthy and MDMV-infected sweet-corn cultivars were collected in the field and then germinated *in vitro*. Vigor was measured as percent germination and as average germ tube length. Viral infection did not affect germination percentage of the pollen, but did reduce pollen germ tube length *in vitro* in five of the seven cultivars.

The leaves of this corn plant show the mottling that is a common symptom of MDM.

But does pollen growth *in vitro* duplicate growth in the living silk? To answer this question, we next measured pollen germ tube length in silks *in vivo*. A reduction in the silk's compatibility with pollen because of MDMV infection could also contribute to butt blanking. We therefore crossed pollen from healthy and infected plants on silks from both sources. This method had two advantages. It allowed us to measure pollen germ tube length directly in the living silk and also to test the compatibility of silks and pollen from both healthy and infected plants.

We found that when either or both parents are MDMV infected, pollen germ tube length in silks is reduced. Thus the infection of either parent in the field can contribute to butt blanking, resulting in reduced ear weight. The extent of yield reduction depends on when the plant is infected, its tolerance to the disease, and environmental stresses.

Control of MDMV

The virus can best be controlled by using resistant varieties. In an attempt to find resistance in sweet corn, we screened more than 400 lines, but noted only slight degrees of tolerance. The next step is to incorporate the resistance in field corn into sweet corn, a task that many breeders throughout the country are now working on. In a few years this work is expected to result in the release of several resistant lines that should enable growers to combat maize dwarf mosaic.

Membership and Voting Rights In Illinois Cooperatives

DENNIS CONLEY and KEVIN B. LEWIS

FARM COOPERATIVES go back more than a century and a half in this country. During the intervening years, dozens of grain marketing cooperatives have been formed in Illinois to meet the needs of their owner-users. Although these cooperatives serve a similar purpose, they are not identical in the way they are organized. Some of the differences among them were the subject of a study done two years ago in Illinois.

Background

Over the years cooperative pioneers and leaders have developed at least nine principles for operating cooperative firms. The principle that most concerns us in this article is democratic control. Managers and boards of directors are responsible for creating policies consistent with these established principles.

Democratic control has two components: (1) member ownership, which is achieved through investment of equity capital in the cooperative, and (2) member control, which is exercised primarily through voting. Ideally, when these components are properly aligned, the same individuals both own and control their cooperative.

As long as members sell their grain through the cooperative, they clearly have an interest in determining how it should be organized and operated. But at some point in time a member stops patronizing the cooperative and chooses to retire. In this case, a procedure is needed for the member to relinquish control by giving up voting rights and for the cooperative to return equity capital to the retiring member.

Membership and voting policies

Each cooperative has its own way of providing for democratic control and for the return of equity. The purpose of our study was to describe membership and voting policies and to show how their relationship to equity redemption either sustains, limits, or ends a member's control and ownership.

Three policies were considered:

- assignment of a member to inactive status
- termination of inactive members
- provision and basis for voting

We also surveyed the degree of pressure that members exert for adoption or modification of an equity redemption program.

Our sample included 27 grain cooperatives, or about a fifth of those in Illinois. Two-thirds of them have some type of equity redemption program, while the rest do not. In general, the cooperatives with redemption programs have some sort of bylaw provision for systematic or special return of equity; the nonprogram cooperatives have no such provision.

Every cooperative must decide how to assign inactive status to members who retire, leave farming, or otherwise no longer patronize their cooperative. The board of directors makes the decision in 56 percent of all the cooperatives surveyed (Table 1). A bylaw provision is used by 37 percent, and some other method, such as termination of Farm Bureau membership, by 7 percent.

In cooperatives with equity redemption programs, no patronage is the most common criterion used for assigning inactive status. The use of written notification from the member is far less common. In cooperatives with no redemption program, no patronage is evenly split with written notification.

Cooperatives also consider the number of years of no patronage in assigning a member to inactive status. None of the program cooperatives assign a member after only one year (Table 1). In contrast, 33 percent of the nonprogram cooperatives assign members to inactive status after one year of no patronage.

A policy matter closely related to status assignment is whether to terminate inactive memberships. According to survey results, 44 percent of the program cooperatives terminate inactive memberships and 56 percent do not. The reverse is true of the nonprogram cooperatives (Table 1). Equity may or may not be returned upon termination, depending on the cooperative's policy.

When cooperatives assign inactive status to a member, they must decide whether the member will have full or limited voting rights. Members placed on inactive status but not terminated are allowed to vote in 70 percent of the program and in 75 of the nonprogram cooperatives (Table 1). Half of the program and two-thirds of the nonprogram cooperatives limit the vote in one of two ways: either by the number of votes allowed or by the number of shares of stock a member may hold.

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Table 1. — Assignment to Inactive Status and Subsequent Voting Rights of Members in Grain Cooperatives in Illinois, 1977-1978

	All cooperatives surveyed, N = 27	Program cooperatives	Nonprogram cooperatives
		percent	
Method of assignment			
Board decision	56	56	56
Bylaw provision	37	39	33
Other[a]	7	6	11
Criterion			
Years of no patronage			
One year	11	0	33
Two years	15	22	0
Three years	26	39	0
Four years	7	6	11
Total, all years	59	67	44
Member statement[b]	22	11	44
Other[a]	19	22	11
Termination policy			
Terminated	48	44	56
Not terminated	52	56	44
Voting rights of inactive members[c]			
Vote	71	70	75
No vote	29	30	25
Voting limitations			
Limitations[d]	56	50	67
No limitation	44	50	33

[a] For example, termination of Farm Bureau membership or moving from the area.
[b] A member's written notification to the cooperative.
[c] Assigned to inactive status but not terminated.
[d] Limits are either on the number of votes a member may exercise or on the number of shares of stock a member may hold.

Withdrawal of voting rights

Now let us look at various criteria used for assigning members to inactive status and for terminating membership. What are the overall chances of members being denied voting rights once they meet the criteria for inactive status? The chance is 60 percent for program and 67 percent for nonprogram cooperative members.

Here we are dealing with two categories of members: those put on inactive status and those whose memberships have subsequently been terminated. A further breakdown of the survey data shows that, after one year of no patronage, slightly more than half of these people in nonprogram cooperatives will have voting rights withdrawn, compared with none in the program cooperatives. After three years, people in these categories in both types of cooperatives stand an equal chance of being denied their vote.

Note, however, that some program cooperatives use a three-year period of retirement from farming as a condition in qualifying for equity redemption. In contrast, nonprogram cooperatives have no such provision for returning equity (ownership) to members.

Pressure to change policy

Quite obviously the ideal of member ownership and control is not realized in many instances. But do members exert pressure either to adopt equity redemption programs or modify existing ones? As part of the 1978 survey, we gathered information to help answer this question.

We found that no changes had been proposed in 78 percent of either type of cooperative for at least five years before the study. Furthermore, only about a fifth of the cooperatives had discussed such changes, and none had followed through in making any modifications.

Contrary to the principle of democratic control, members do not seem particularly concerned about losing control in the cooperative where their money is invested. Perhaps members lack an understanding of ownership and control. Or perhaps managers and boards of directors fail to recognize a split between the two aspects of the principle or are reluctant to do anything about it. Apathy may be another reason that members do not challenge the loss of voting rights.

Boards of directors need to review their cooperative's policy to be sure that the same individuals retain control along with ownership. Preferably these individuals will also patronize the cooperative. Depending on what the members agree to, control can be based on a one-member, one-vote system or on proportional voting. But regardless of the system, members should not be denied voting rights as long as they have equity in the cooperative. If they are not allowed to vote or if the right is seriously limited, then policy revisions are needed to link control to equity.

Unless all equity has been returned, even past members should have the right to vote. If such is not the case, voting and redemption policies need to be revised. Revision is particularly critical for nonprogram cooperatives. These policies should apply to all members, including those who are inactive because of no patronage or because of a decision by the board of directors. Members who choose to withdraw through written notification should be protected by a specific provision that allows them to continue voting while their equity is still in the cooperative.

A formal equity redemption program that spells out voting rights in relation to equity redemption can guard against inadvertently establishing policies contrary to the principle of democratic control. Boards of directors, managers, and members alike have a major responsibility to adopt the necessary policies. As young members replace those who retire, these policies need to be well developed and understood by all.

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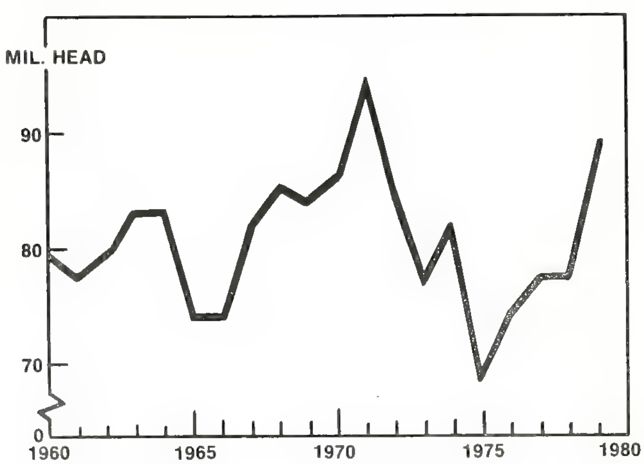
FARM BUSINESS TRENDS

A downturn in the current hog cycle is indicated in the U.S. Department of Agriculture's June "Hogs and Pigs" report. According to the inventory of market hogs, slaughter this fall should be slightly above that of last year. But reduced numbers of breeding stock and plans for less farrowing point to a reduction in slaughter for 1981.

The build-up has continued since 1975 in contrast to the usual pattern of increasing production for two years followed by a decline the next two years (see graph). On the heels of the short 1974 corn crop, hog numbers dropped sharply, with only 69 million head being slaughtered in 1975. This figure is by far the lowest in the last twenty years.

Even while hog numbers follow a cyclical pattern, the industry has seen many changes. For example, in 1978 Illinois had an estimated 33,000 hog farmers, compared with more than 80,000 in 1960. The national trend has been quite similar. Total hog production has not changed greatly, but output per producer has risen dramatically. Farms producing 5,000 hogs or more account for an estimated 16 to 17 percent of the present U.S. production. Units selling more than 1,000 hogs provide 40 percent of the total, compared with only 7 percent in 1964. Studies indicate a rapid increase in these large units. The move to confinement units, which use advanced technology to lower labor requirements, is helping this trend.



U.S. commercial hog slaughter, 1960 to 1979.

Production remains heavily concentrated in the Midwest. Iowa normally accounts for about 25 percent of the hogs marketed in the United States. Illinois is in second place, with an average of about 12 percent of the total production. Although some large units are located outside the Midwest, growth has generally been slow there. Also, hog and crop production no longer necessarily go hand in hand, although a feed supply nearby is still desirable.

Indications are that the trend toward fewer but larger producers will continue. The downturn in the present cycle will accentuate this trend, resulting in the continuation of a more uniform seasonal marketing pattern than in the past. In 1979 per-capita pork consumption was just over 70 pounds. Slightly less than 70 pounds appears to be the limit of a profitable market for pork, particularly as poultry production rises. Illinois will probably maintain its position in total output, with expansion of the industry only in proportion to increases in U.S. population. — *M. B. Kirtley, Extension economist in livestock marketing*

Fall, 1980

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

IN THIS ISSUE

At the Dairy Research Center, Dr. E. H. Jaster inserts a plastic loop into the milk cistern of a first-calf heifer. The loop may prove helpful in preventing mastitis (page 8).

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE Volume 22, Number 4

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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(Cover picture by Donna Luecke)

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Published quarterly by the University of Illinois Agricultural Experiment Station

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A NEW FORMAT FOR *ILLINOIS RESEARCH*

BEGINNING NEXT SPRING *Illinois Research* will be published in a new format. For many years the journal has presented research reports of broad interest to a varied readership. In the past several years, however, it has become apparent that *Illinois Research* could be a still more effective communication channel if it also contained comprehensive, invited articles and expanded coverage of activities within the Illinois Agricultural Experiment Station.

Changes caused by energy costs, environmental standards, improved research methods, and consumer needs have come rapidly in the last few years. These changes amount to one of the greatest transitions that agriculture has ever faced. Within the Experiment Station we believe that if the research needs of agriculture are going to be met in the most efficient way, then we too must change.

The Station is just completing a staff reorganization. Individual researchers and academic departments will continue to be the foundation for research progress in the Experiment Station. But it has become increasingly important to develop research packages involving interdisciplinary work. It has become equally important to reduce the time between the beginning of a research project and the application of findings.

Illinois Research has been included in our plans for reorganizing. With its new format the journal will provide a channel for the continuous flow of information from the Experiment Station to University of Illinois faculty, the agricultural community, and many other segments of society. — *R. G. Cragle*

Readership Survey

EVERY THREE MONTHS for the last 22 years more than 10,000 copies of *Illinois Research* have gone out to subscribers throughout Illinois, the nation, and the world. Occasionally we meet subscribers face to face, but for the most part we don't know them personally or whether they are satisfied with the publication.

Last spring we surveyed our readers to learn about their interests, backgrounds, and preferences. Under the direction of the Survey Research Laboratory, questionnaires were mailed to 500 subscribers selected at random from the mailing list. The response was gratifying: 353 questionnaires (71 percent) were returned.

Reader interest

The vast majority of respondents (96 percent) read or skim all four issues per year, and 70 percent read or skim most or all of the articles in each issue. About two-thirds of the subscribers pass the journal along to at least one other person, but in some cases a single copy may be seen by many other people.

	Pct. of respondents
Issues read or skimmed per year	
4 issues	96
3 issues	2
1 or 2 issues	2
Articles read or skimmed per issue	
Every article	17
Most of the articles	53
Some of the articles	28
Very few articles	2
Others who see subscriber's copies	
No others	34
1 other	31
2 others	17
3 to 9 others	15
10 to 70 others	3

Illinois Research publishes brief reports of research and Extension activities from twelve units, each with many specialties, in the Colleges of Agriculture and Veterinary Medicine. So much diversity means that we are able to offer something of interest to people from many walks of life. As expected, a fair proportion of our readers are farm operators (23 percent), but several readers who indicated other occupations said they are farm owners as well. Of the 13 percent who are retired, some had been farmers.

Teachers, researchers, business and agribusiness personnel, and people in Extension work are also well represented among our readers. With very few exceptions, however, health care workers, school administrators, and legislators are not subscribing to *Illinois Research*. Only 10 percent of the subscribers are women.

Occupation	Pct. of respondents
Business, agribusiness	14
Extension adviser	8
Farm operator	23
Health care worker	1
Homemaker	2
Legislator	0
Researcher	15
Retiree	13
School administrator	1
Teacher	16
Other (specify)	7

Not everyone of course fits into the ten occupational categories listed in the questionnaire. Seven percent checked their occupation as "other," including state or federal employee, student, physician, park ranger, agricultural journalist, librarian, oil refinery worker, and investor.

A surprising 70 percent of the respondents had a college degree, and many of those had gone on to graduate school. Twenty percent had a high school diploma or less. Our

	Pct. of respondents
Formal education	
8 years or less	2
9 to 11 years	3
High school graduate	15
1 to 3 years of college	11
College graduate	21
Graduate work	49
Age of respondent	
21 or under	1
22 to 30	13
31 to 45	28
46 to 65	40
66 or over	18

readers appear to be considerably better educated than in 1961, when the previous *Illinois Research* survey was conducted. At that time the figures were almost reversed: only 20 percent had graduated from college, while 63 percent had a high school diploma or less.

Despite occupational, educational, and age differences, subscribers share similar reasons for reading *Illinois Research:* to keep up to date on new ideas or techniques (49 percent), to learn what college scientists are doing (20 percent), and to obtain information applicable to their work (28 percent).

Over the years we have tried to strike a balance in our reporting style, one that accommodates differences in occupation and levels of education. Apparently we have been reasonably successful in achieving that balance: 94 percent of our readers indicated that the writing style for most of the articles is about right, not too simple and not too difficult.

Interestingly, a few of the respondents who had a high school education or less found the style too simple. On the other hand, one respondent who had done graduate work felt that the style was too difficult — for readers with less than a college education.

Table 1. — Choices for Topic Areas of Interest to Readers

	First	Second	Third
		Percent	
1[a] Agronomy	25	15	10
2 Agricultural economics	16	15	8
3 Farm business trends	8	13	15
4 Horticulture	11	8	7
5 Agricultural engineering	9	7	7
6 Animal science	7	9	7
7 HRFS[b]	6	4	6
8 Plant pathology	2	7	8
9 Food science	4	5	6
10 Entomology	4	5	6
11 Dairy science	3	4	2
12 International agriculture	1	3	9
13 Forestry	2	3	4
14 Veterinary medicine	2	2	6

[a] Rank order was determined by assigning 3 points for a first choice, 2 points for a second, and 1 point for a third. All points for each topic were then added.
[b] Human resources and family studies (formerly home economics).

To find out what subjects *Illinois Research* subscribers are most interested in, we listed fourteen broad topic areas and asked readers to indicate their first, second, and third choices (Table 1). About half of the respondents ranked agronomy, agricultural economics, and farm business trends the most interesting topics, with horticulture running a close fourth.

A bit of caution must be used in interpreting these responses: topics that were not among the three most popular were not automatically considered uninteresting. In fact a number of readers commented that they find all of the topics interesting, but that some are a little more so than others.

Furthermore, some areas of research may be of interest to only a small segment of the readership, but many people benefit indirectly from work in those areas. The ranking of food science provides a telling example. Everyone must eat, even though not everyone cares to read about what scientists are doing to help improve our diet. A somewhat similar interpretation holds true for topics such as dairy science or international agriculture.

New format

In recent years the shape of agriculture and the direction of studies in human resources and the family have changed considerably. New demands are being placed on the Illinois Agricultural Experiment Station and, as a consequence, on *Illinois Research*. Because of the public's need to be informed of these changes, we feel an obligation to bring our readers expanded coverage along with in-depth treatment of timely subjects.

Readers' opinions about some proposed changes in the form of reporting are important to us. In the survey we therefore asked a series of questions related to content and format.

Three-fourths of the respondents said they would like more articles on practical topics, and a little more than half said they would like to see more articles that are research oriented. In response to an open-ended question, many readers suggested that we include a section of news briefs for broader coverage and that we publish more articles per issue or more issues per year. Apparently a substantial number of subscribers are as interested in receiving information about ongoing research projects sponsored by the Experiment Station as we are in communicating the results.

In favor of having:	Pct. of respondents
More articles on practical topics	75
More research-oriented articles	59
Special issues with in-depth treatment of one topic	67
More photos and illustrations	47
Use of color	27
New cover design	9

Two-thirds of our readers like the idea of having special issues that treat a single topic in depth. For instance, in a future issue we hope to take a close look at what is being done to create economical, renewable sources of energy in Illinois and how to use our nonrenewable sources more efficiently.

Many readers (47 percent) indicated that they would like to see more photographs and illustrations than the publication now carries. Although a fourth of the respondents would enjoy the use of more color, several said they realize it increases the cost of production.

Some readers were cautious in giving the go-ahead for change. As one person aptly put it: "My wife and I enjoy *Illinois Research* as it is, but if you feel new changes are in order, we would encourage you to implement them." And another reader commented: "Don't change it too much as I feel the publication is quite good as is. The price is right also!"

Other comments were valuable, too. For example, five readers suggested that we include a list of articles and books related to the topics discussed. A letters-to-the-editor department and occasional updates on continuing research projects were also among the suggestions.

A gap that needs to be bridged is the one between the Experiment Station and people living in large cities and their suburbs. According to survey findings, only 3 percent of *Illinois Research* subscribers live in cities of more than 250,000 people, and 9 percent live in the suburbs. In the future we hope to reach still more urban and suburban residents who may be interested in Experiment Station activities.

Place of residence	Pct. of respondents
Large city, 250,000 or more	3
Suburb of large city	9
Middle-sized city, 50,000 to 250,000	15
Small city, 10,000 to 50,000	17
Town of less than 10,000	16
In country but not on farm	8
On farm	32

One respondent suggested that we shouldn't wait another nineteen years before sending out survey questionnaires again. We agree. Meanwhile, *Illinois Research* contributors and editorial staff would like to hear from readers between surveys. Comments are welcome anytime.

— *S. A. Ryan, editor*

JANE A. SCHERER

Phone the Consumer Call-In

IT'S NOT DIRECTORY assistance and it's not the time and temperature. But among telephone information services, 737-1370 is one of the busiest numbers in the Chicago area.

The service is known as the Consumer Call-In, which has answered more than 65,000 questions since April, 1977. Operators on duty from 9:00 a.m. to 4:00 p.m., Monday through Friday, can take calls in English or Spanish.

The Call-In is part of the Consumer and Homemaking Education Program (CHEP), conducted by the University of Illinois Cooperative Extension Service. Financial assistance comes from the Illinois State Board of Education, Department of Adult, Vocational, and Technical Education.

By referring to a card file, the operators answer questions about family economics, community resources, food, clothing, health, gardening, family life, home furnishings, and housing. Each of the 550 cards on file supplies information for a single idea. About 10 percent of the questions asked are not on file. If the operators are unable to find an answer, they take the caller's name and phone number and refer the question to an Extension assistant who works closely with specialists at the university. The question is researched and the answer relayed back to the consumer, usually within 48 hours.

Questions vary greatly. Recent questions include: "Can I sterilize baby bottles in my microwave oven?" "How do I make strawberry jam?" "Where can I go to learn to speak English?" "Where can I get a mortgage for 5 percent down?" "How can I fix a window screen?" "What should I consider when buying a new mattress?"

Recently a study was conducted to determine the effectiveness of the Consumer Call-In. The survey sample consisted of 203 people who had used the service. Questionnaires were administered by telephone interview, unless a caller requested that the questionnaire be mailed.

Before discussing the findings, two qualifying statements should be made. First, the sample cannot be considered scientifically random, because names were received in an uncontrolled manner and thus may not be representative of all Consumer Call-In users. Second, the callers during any given period are determined by the type of medium being used to advertise the service at the time. During this survey, newspaper articles and radio programming were used most extensively.

Call-In users

One objective of this survey was to determine the demographic characteristics of Call-In users. Respondents were asked to give their age group, education completed, 1978 income before taxes, marital and employment status, sex, and number of adults and children in the household.

Users represented all age groups. The young (19 to 24) and the elderly (over 65) were the smallest groups, with only 8 percent of the respondents falling into these ranges. The remainder fell into the middle-aged category (35 to 44, 45 to 54, and 55 to 64), with slightly more than 20 percent in each group.

A high proportion of callers, 34 percent, had college or advanced degrees. At the other extreme, 3 percent had completed grade school only; another 3 percent had not finished high school. The two groups with the highest frequency were high school graduates (24 percent) and those with some college (24 percent). It is interesting to note that some respondents were nutritionists or home economists who used the Consumer Call-In to get answers to their more technical questions.

As with education, the income distribution was slightly upwardly skewed, with 42 percent of the respondents reporting incomes of more than $20,000. Seven percent reported incomes of $5,000 or less, and 6 percent had household incomes between $5,000 and $10,000. The range most frequently reported was $25,000 to $30,000; 19 percent of the respondents were in this range. The next most frequently reported range was $15,000 to $20,000, with 15 percent in this category.

Most of the respondents (77 percent) were married. Only 9 percent were divorced or widowed, while 12 percent were single homemakers. As might be expected, 92 percent of the respondents were female.

Slightly more than half of the callers were unemployed. Of the 47 percent who were employed, three-fourths of them worked full time and the rest part time. It is surprising that such a large percentage of callers are employed, considering that the Call-In hours are 9:00 a.m. to 4:00 p.m. on weekdays.

Because the service gives information to help families use their resources to the best advantage, much of the information probably benefits not only the caller, but also others in the same household. Although 52

Jane A. Scherer is a Consumer and Homemaking Education Program (CHEP) coordinator. Members of the research staff were Sharon Litherland and Lynn Eslinger, CHEP Extension assistants; and Susan Raines, evaluation consultant.

percent of the respondents indicated that they had no children under 18 years of age residing in the household at that time, the remaining 48 percent did. Seventeen percent of the total respondents reported having one child, 17 percent two children, and 14 percent three to six children living at home.

Method of delivery

What are callers' preferences for receiving information? Do they prefer the telephone or do they want to get educational information in other ways?

Callers were asked which of the following methods they prefer: visiting an office, using the telephone, attending a meeting, listening to the radio, watching television, reading newspaper articles or newsletters, or having a resource person come to their home. Of the 181 responses received, an overwhelming 84 percent stated that they prefer using the telephone. The second most frequent response was the conditional statement, "Depends on the question"; 5.5 percent gave this response. The other methods of information delivery were far less popular.

Use of information

The essence of the Call-In service is the accuracy and usefulness of the information given to consumers. Several questions in the survey attempted to determine how consumers use this information. Respondents were asked if they had tried the operator's suggestions. At the time of the interview, 87 percent had tried them. Many Call-In questions, such as how to remove paint from woodwork, are answered with step-by-step procedures that may require some time to perform. Thus some respondents had not yet had time to try the recommendations.

The respondents were also asked if the information had been helpful; 95 percent felt that it had. When asked if they had used the information more than once, 49 percent responded yes. This finding indicates that the service is not merely a one-time source of information.

Users were asked if they had shared Call-In information with a friend or relative. Of 173 respondents, 118 or 68 percent said they had shared information, an indication that the service is reaching many more people than just the callers.

Caller satisfaction

To determine how callers feel about the service, respondents were asked a series of questions dealing with three major areas: the operators, the information relayed, and the caller's satisfaction with the service.

The operator's role is a complex one. Operators must be responsive, polite, and friendly at all times; be able to pinpoint and understand fully the callers' questions; have full knowledge of the Call-In files; and be able to retrieve information quickly. Operators are also responsible for accurately relaying answers from the university to consumers when information is not on file. Pleasing a caller in all these ways is not simple.

In the survey we asked two questions relating to the operator with whom respondents had talked. They were asked if they felt the operator had been pleasant. An outstanding 99.5 percent were positive.

To the second question, "Did the operator's response answer your question?" 89 percent replied yes and the remaining 11 percent no. Callers may not receive answers for one of several reasons: (1) A caller's problem may not have a known solution. For example, there is no known method for removing certain types of glue from fabrics. (2) Some callers who are referred to another agency may feel that their questions are not adequately answered. It is Consumer Call-In policy to encourage consumers to become more aware of community and government resources. The operators therefore refer consumers to the agency or office that has the authority to help them. (3) Operators cannot and should not answer some questions, such as requests for legal or medical advice. For these reasons, some callers felt that they had not received an adequate answer.

When asked, "Were you satisfied with the service?" 92 percent responded yes. This high degree of satisfaction is further evidenced by the 71 percent who reported having told someone else about the Consumer Call-In.

The 8 percent who were not satisfied felt that the operator had not answered their question. It should be noted that almost half of the dissatisfied callers did not prefer the telephone information delivery system. Also, higher percentages of the dissatisfied group were college graduates or those with more advanced degrees. In terms of income, half of the dissatisfied group were reluctant to report their income range.

Use of Extension programs

An important aspect of the study was to determine if the callers surveyed had participated in other Extension programs before using the Call-In. A significant number had never before been involved with Extension programming. Only 24 percent had read Extension newspaper articles, and still fewer (16 percent) had telephoned an Extension office sometime before using the Call-In. Extension's most common delivery methods — public meetings and newsletters — received the lowest responses: 6 percent for meetings and another 6 percent for newsletters.

Consumers' response

Reactions to the Consumer Call-In can best be summarized in the words of a few users:

- "I like getting the information I need by phone. If I have additional questions or need further explanation, I can ask right away."
- "I find it cheaper, even with a toll charge, to phone the Consumer Call-In than to run around in the car or go to the library."
- "The Consumer Call-In gave us immediate, helpful, and practical information leading to a solution of our problems without the need to seek help outside the family."

Planting Date, Starter Fertilizer, and Corn Yield

W. M. WALKER and D. L. MULVANEY

AN ADEQUATE QUANTITY of fertilizer, along with early planting of an adapted variety, has long been recognized as important in producing high corn yields. Under some conditions, "starter" fertilizer is applied to corn to promote rapid plant growth. Several years ago producers were urged to use "popup" fertilizer at seeding to supply the developing seedling with nutrients.

During the past few years we have been doing research at the Agronomy Research Center in DeKalb County to measure the effects of popup and starter applications, nitrogen rate, and planting date on corn yield. This report summarizes part of our findings.

Planting dates

Four planting dates were selected for evaluation. The earliest were from the latter part of April to May 2 and the latest from May 22 to June 15. Because of weather conditions we were unable to begin planting on the exact same date each year. Therefore for convenience the dates are indexed as early, moderately early, moderately late, and late.

Within any given year, the early or late designation reflects not only a calendar date, but also weather conditions as they affected the time of planting. Commercial producers face the identical need for adjusting planting date because of adverse weather.

Fertilizer rates

Nitrogen rates varied from zero to 240 pounds per acre. The rate for the starter fertilizer, 8-32-16 (N-P_2O_5-K_2O), was 150 pounds per acre, and 33 pounds for the popup fertilizer, also 8-32-16. The starter was applied to the side and about 2 inches below the seed. The popup was applied with the seed.

Phosphorus and potassium levels in the experimental plots were maintained by broadcasting the appropriate fertilizer before planting. Soil tests averaged 6.7 for pH, 34 pounds per acre for available phosphorus, and 282 pounds per acre for exchangeable potassium.

Yields

Yields, as affected by nitrogen rate and starter fertilizer, were averaged for six years (Table 1). At the lower nitrogen rates there was a small yield increase attributable to the starter fertilizer. At the higher rates the increase was negligible.

Some researchers have suggested that starter fertilizers may be more effective at an early planting date when the soil is cool than later when the soil is warmer. In cool soils the rate of root growth is slower than in warm soils, and nutrient uptake may be restricted. Placing nutrients near the seedling might therefore be an advantage.

Average yields resulting from the use of starter fertilizer applied at various planting dates are presented in Table 2. Although there was a small yield response of about 2 bushels per acre with the starter, our results do not show a significant interaction between planting date and starter fertilizer.

The effect of planting date and nitrogen rate on average corn yields is illustrated in Table 3. As planting date was delayed, the yield response to nitrogen fertilizer decreased. At the latest date, the response was negligible beyond the 80-pound rate.

At the early and moderately early dates, however, yields did respond to the highest nitrogen rates. This finding reinforces the longstanding recommendation of Illinois agronomists that higher rates of nitrogen be used for corn planted early in the season.

Yield increases from applications of popup fertilizer often receive considerable publicity. But our results from DeKalb have shown inconsistent responses. Although yields varied from year to year, the average over three years was 149 bushels per acre both for plots with and those without popup fertilizer. It may be worthwhile north of Illinois, but our results do not support a recommendation for this state.

Results from this study show that early-planted corn responds better to higher nitrogen rates than does late-planted corn. At the higher nitrogen rates, neither starter nor popup fertilizer had any significant effect upon yield.

Table 1. — Effect of Starter Fertilizer and Nitrogen Rate on Corn Yields

N, lb/A	No starter	Starter
	bu/A	
0	122	128
80	148	150
160	158	159
240	160	160

Table 2. — Effect of Starter Fertilizer and Planting Date on Corn Yields

Planting date	No starter	Starter
	bu/A	
Early	152	155
Moderately early	156	157
Moderately late	151	153
Late	131	133

Table 3. — Effect of Nitrogen Rate and Planting Date on Corn Yields

N, lb/A	Early	Moderately early	Moderately late	Late
		bu A		
0	126	129	131	116
80	153	157	153	134
160	166	169	161	138
240	169	172	162	139

W. M. Walker is professor of biometry and soil fertility; D. L. Mulvaney is agronomist in the Department of Agronomy.

The Plastic Loop And Mastitis Prevention

E. H. JASTER, T. A. McPHERRON, and A. R. SMITH

MASTITIS IS A COSTLY disease that afflicts more than half of the 10.7 million dairy cows in the United States. Sooner or later these cows will have some form of mastitis in one or more quarters. Recent reports estimate that annual losses from mastitis average $200 per cow. The total loss exceeds $1 billion.

Antibiotic residues

Mastitis is usually treated with antibiotics, which are coming under renewed scrutiny. Since July 1, 1980, the Food and Drug Administration requires that a new antibiotic test be used for monitoring the adulteration of milk. With the *Bacillus stearothermophilus* procedure, the presence of penicillin in concentrations of 0.006 I.U. per milliliter can now be detected. The test is ten times more sensitive than the previously used *B. subtilis* test.

Antibiotic residues in milk are associated with the treatment of mastitis and other diseases in dairy cows. If the milk of treated cows is marketed too soon after treatment, antibiotics are often present in the milk. Because of the new test, more milk will undoubtedly be withheld from the market than in the past.

Antibiotics for treating mastitis have been a help to dairy farmers. But cost of the drugs, losses from discarded milk, and the declining effectiveness of antibiotic treatment in some cows are recurring problems. Nonantibiotic control of mastitis is a possible alternative.

E. H. Jaster is assistant professor of dairy science; T. A. McPherron, assistant professor of veterinary clinical medicine; and A. R. Smith, assistant professor of veterinary pathobiology.

Plastic loop

Such control involves altering and manipulating the naturally occurring factors in milk secretions that are associated with the cow's defense system. The plastic loop is one alternative that shows promise for helping to prevent mastitis.

An innovative device, the loop is made of polyethylene plastic about 5 inches in length and ⅛ inch in diameter. It takes a circular shape when inserted into the milk cistern of each quarter. Once in place, these loops appear to cause a mild irritation with a subsequent increase of leukocyte numbers in the gland.

During a process known as phagocystosis, leukocytes or white blood cells "recognize" chemical messengers that signal bacterial invasion. Formed from damaged cells or bacteria, these messengers cause large numbers of leukocytes to move into the irritated or infected area. Here they engulf the pathogen, killing it with destructive enzymes and proteins.

Normally this process occurs 24 hours after the invasion of mastitis-causing bacteria. If the bacteria multiply before the leukocyte response, they can become established in the udder. But we have reason to believe that the loop, by causing a mild irritation in each quarter, will increase the normal leukocyte levels before invasion. These greater numbers will then be on hand to destroy the invading bacteria, thereby reducing the time needed for the udder to respond to infection.

Still in the early stages, research is being conducted at our Dairy Research Center to determine if the plastic loop will cause localized formation of leukocytes and if the increased response will prevent mastitis. The loops have already been inserted into two teats of each of ten first-calf heifers. All ten have recently calved and have no history of mastitis. Eventully a total of 20 lactating heifers will be used in the study.

Initial results from the first three months of data collection indicate that leukocyte numbers have increased in those teats containing the loops. This finding is based on samples of foremilk, bulk, and strippings taken from all four quarters of the ten lactating heifers. (Foremilk is the first milk and strippings the last milk obtained during milking, while bulk is a composite sample.)

We are using bacteriological analysis of aseptically collected foremilk samples to monitor the heifers for clinical and subclinical mastitis. Preliminary counts show a significant increase in the number of leukocytes produced by the treated quarters (Table 1). So far the loop has not affected the milk yield, percent milk fat and protein, or electrical conductivity of the milk.

In the future we plan to study the response of the udder to infusion of

Table 1. — Leukocyte Counts in Various Fractions of Milk From Quarters With and Without Plastic Loop[a]

Fraction measured	No loop (control), cells/ml	Loop, cells/ml
Foremilk	200,000	1,800,000
Bulk	140,000	1,100,000
Strippings	440,000	3,200,000

[a] Each value represents the mean from 10 animals.

mastitis-causing bacteria. The objective will be to determine whether an increase in the number of leukocytes is sufficient to prevent the bacteria from becoming established in quarters containing the loop. Cows with a history of mastitis may have a delayed reaction to the loop, thus keeping them from being helped by it. Additional tests are needed before the loop can be recommended for mastitis prevention and made available to dairy farmers.

Sanitation

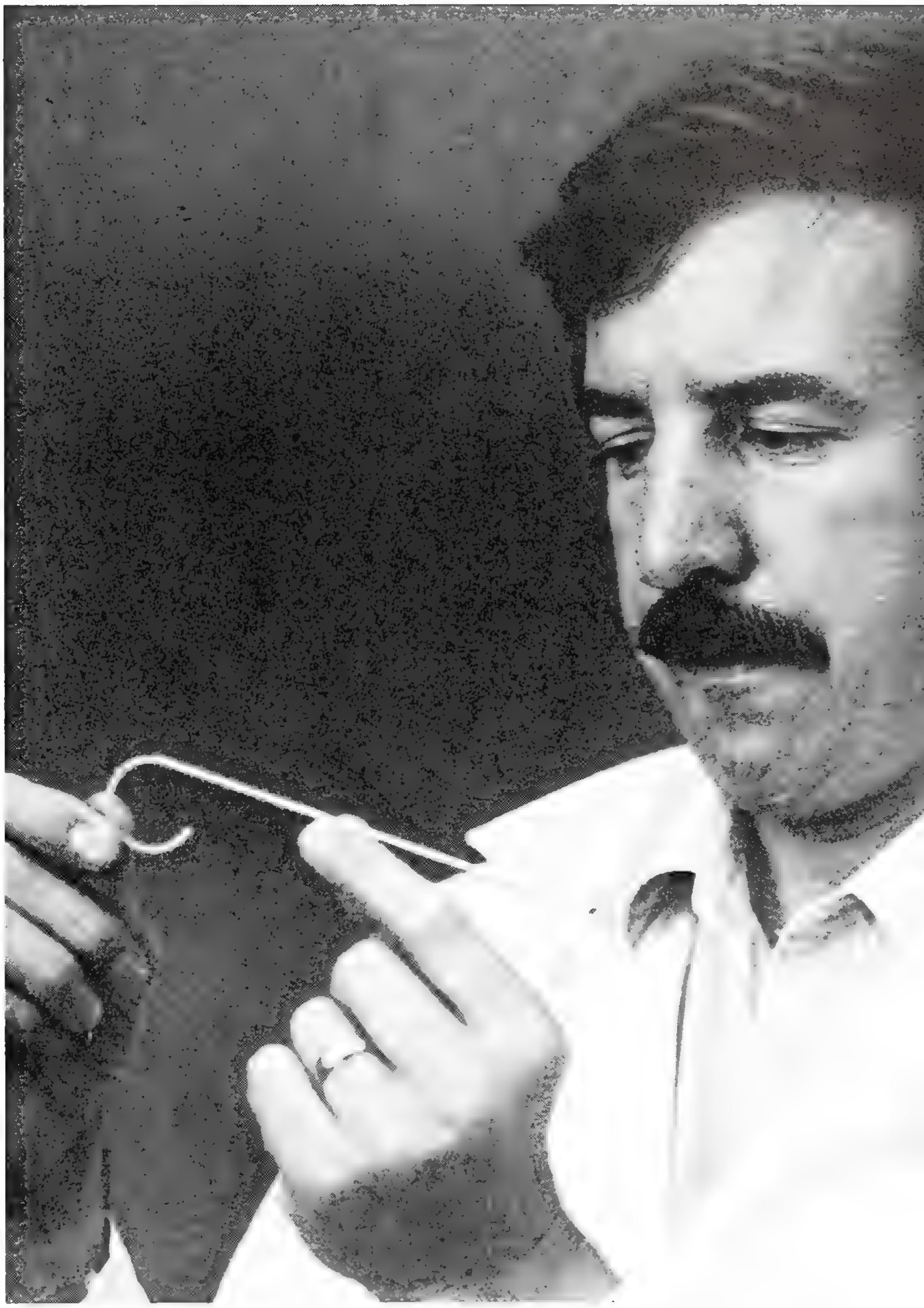
Until then, sanitation is paramount in mastitis prevention. Great care should be taken during milking to reduce transmission of pathogens from the milker's hands, udder cloths, and milk-machine teat cups to the udder. Bacteria can also be transmitted when the cow licks its teats and udder, or when the teats come into contact with the rear legs, tail switch, flies, and contaminated bedding. Several sanitary practices are necessary for effective control.

Disinfecting milker's hands. Research in England has shown that the use of disinfectants or rubber gloves reduces the number of pathogens on the hands of milkers.

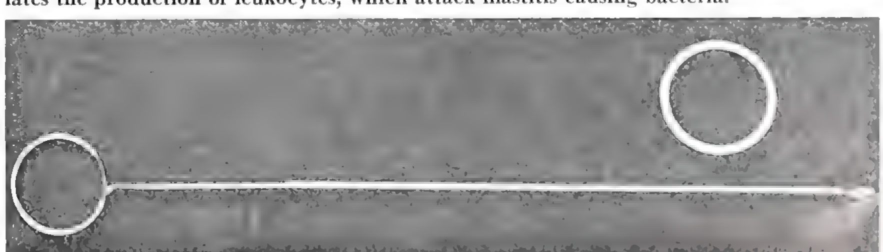
Udder washing. Washing udders with a sanitizing solution removes dirt and organic matter, destroys mastitis organisms, promotes milk let-down, and improves milk quality. But excessive use of these solutions should be discouraged, because pathogens can be spread rather than destroyed on udders that are too wet. Single-service towels or heat-sterilized cloths should be used to dry the udder before teat cups are attached.

Disinfecting teat cups. Disinfecting cup liners between cows reduces the number of pathogens transferred by the milking machine, according to research in the United States and England.

Teat dipping. The use of disinfectants after milking will destroy pathogens remaining on the teat. Louisiana researchers recommend that teat coverage be sufficient to reduce any new intramammary infection.



Author E. H. Jaster threading a plastic loop into a catheter. Shown one-half of actual size (bottom right), the coiled loop is 5 inches long when fully extended. A catheter is inserted through the cow's teat (see cover photo) into the milk cistern. There the loop is released by means of a plunger (bottom left). When in place, the loop stimulates the production of leukocytes, which attack mastitis-causing bacteria.



Clothing Care: Products And Methods

DEBBI LASHBROOK and MARJORIE SOHN

When it comes to clothing care, today's consumers are faced with many choices. Thanks to technology, we have a wider selection of fibers and fabrics than thirty years ago. Industry in turn has been developing cleaning products and appliances to complement our modern fabrics. As a result, most consumers have come to expect apparel that's easy to care for and products to help them do so.

Clothing and clothing care equipment are due for still more changes in the 1980s. For example, the energy problem has created interest in energy-efficient appliances. With thermostats being set higher in summer and lower in winter than in the past, consumers will be looking for more comfortable fabrics. And public concern about the effects of waste products discharged into waterways has already led to a reformulation of many laundry detergents.

But so many choices and changes sometimes leave homemakers confused. Before we can plan effective programs to help people learn to care for their clothing, we must identify the needs or problems of particular groups, as well as the products and practices currently used.

A survey was conducted in Champaign County, Illinois, to find out how much consumers know about clothing care, what methods they use, and how satisfied they are with the results. Information about age, income, level of education and the like was also gathered and then correlated with the findings.

Data were collected through face-to-face interviews with 225 homemakers randomly selected from among rural and metropolitan-area residents. The respondents were female homemakers, 18 years of age or older, who had the primary responsibility for clothing selection and care in the household. The vast majority of them did the laundry themselves.

Debbi Lashbrook, formerly an instructor in textiles and clothing, is now assistant to the director of the School of Human Resources and Family Studies. Marjorie Sohn is associate professor and Extension specialist in textiles and clothing.

Sample characteristics

Not quite half of the respondents lived in Champaign-Urbana at the time of the survey; the rest lived outside the city (Table 1). A great percentage of them lived in single-family homes with two to four members in the household.

The majority of homemakers reported a family income of $12,000 or more. Respondents with a high-school diploma or with some college, business, or technical training were also in the majority. Mean age of the women was 39 years; a third fell into the age range of 40 to 59 years.

Half of the respondents were full-time homemakers; the other half worked outside the home as well. The number of women holding outside jobs was almost evenly distributed among three categories: professional, technical, or managerial; clerical or sales; and blue collar.

Table 1. — Characteristics of 225 Respondents in Survey of Clothing-Care Methods, Champaign County, Illinois

	Number	Pct. of total
Place of residence		
Champaign-Urbana	98	44
Champaign County (not in city)	126	56
Type of housing		
Single-family home	178	79
Duplex	3	1
Apartment	30	13
Mobile home	14	6
Number in household		
1	27	12
2	74	33
3-4	87	39
5 or more	37	16
Annual income		
$ 4,999 or less	29	13
$ 5,000-$11,999	40	18
$12,000-$19,999	62	27
$20,000-$29,999	42	19
$30,000 or more	13	6
No income reported	39	17
Respondent's education		
Less than high-school diploma	45	20
High-school diploma	74	33
Some college, business, or technical training	63	28
College graduate	42	19
Respondent's age		
25 years or less	54	24
26-39 years	66	29
40-59 years	71	32
60 years or more	34	15
Mean age	39	. .
Respondent's occupation		
Homemaker	111	49
Professional, technical, or managerial	38	17
Clerical or sales	41	18
Blue collar	35	16

Location of laundry facilities

Three-fourths of the homemakers had an automatic washer in the home; slightly fewer had a dryer. Almost everyone else in the sample used a commercial laundromat or facilities in an apartment building or housing complex.

Whether the washer was located at home or elsewhere was significantly related to the income, age, and education of the respondent, as well as to family size and type of housing. Washer location was not related to occupation, however. With the exception of education, dryer location was related to the same demographic characteristics.

The higher the income and age, the more likely were the respondents to own a washer and dryer (Table 2). Not so with education: fewer women with a college degree owned a washer than did homemakers with less than a high-school diploma. But as might be expected, washers and dryers were more common in larger families than in smaller ones.

Two-thirds of the respondents over 25 years of age were satisfied with their laundry facilities, probably

Table 2. — Percentage of Respondents Owning Washers and Dryers, by Income and Age

	Washer	Dryer
	Pct.	
Income		
$20,000 or more	90	95
5,000 or less	40	28
Age		
26 years or more	70	84
25 years or less	40	31

because many of these women owned a washer and dryer. Only half of the women under 25 were reasonably satisfied. Many of the dissatisfied (72 percent) lived in apartment buildings with frequently malfunctioning equipment.

The majority of respondents (60 percent) used line drying for the family wash at least some of the time. But line drying was more common among women having incomes below $12,000 and a high-school diploma or less than among their more affluent, better educated counterparts. Almost all of the rural homemakers (90 percent) and all of the blue-collar respondents dried their laundry outdoors whenever practical.

Frequency and sorting

Number of loads washed per week ranged from one to 15 or more: 45 percent of the women washed fewer than 5 loads, 27 percent washed 5 to 10, and 11 percent washed 15 or more loads. Almost all of the women interviewed sorted their laundry before washing. More than half sorted according to color and type of article. The rest sorted by fiber content, fabric construction, and type and degree of soil. The practice of sorting laundry was not significantly related to any of the sample characteristics.

Source and quality of water

Water — where it comes from and how hard it is — can influence the choice of laundry products and the amount needed for satisfactory results. Two-thirds of the survey respondents used a city water supply, 10 percent used well water, and the rest did not know the source. The water was considered very soft or moderately so by two-thirds of the homemakers, and moderately to very hard by a fourth; the remainder did not know.

Relatively few homemakers (16 percent) used a water softener. About half of those who did use one had a mechanical softener attached to the water lines, while a fourth used packaged softeners.

Whether to use hot, cold, or warm water is another choice that affects washing efficiency. Eight percent usually used cold water; 8 percent, hot; 56 percent, warm; and 28 percent, a combination depending on the items to be washed.

Cleaning products

Most respondents (86 percent) used a regular powdered detergent, but some also used a cold-water powdered detergent (22 percent) or a cold-water liquid detergent (15 percent). Almost everyone who used a cold-water liquid detergent was over 25 years of age and lived in a rural area.

About three-fourths of the homemakers usually measured the detergent for each load. More of the older than the younger respondents made a practice of measuring the detergent. Of those who did not measure, 55 percent were 25 years old or less. Failure to measure their detergent could in part explain why so many young women (60 percent) indicated they had problems getting clothes clean.

Fabric softeners were routinely used by 84 percent of the sample. The most popular types were those added to the last rinse and disposable, nonwoven softeners. Many employed homemakers used softeners to cut static electricity, while the unemployed used them to make fabrics smell better and feel softer. The different reasons for using a softener may have reflected a difference in fabrics worn at work and at home. The laundry contents of employed and unemployed women may also have been somewhat different.

Three-fourths of the women interviewed bleached their clothes at least occasionally with either a liquid chlorine (62 percent), an all-fabric (32 percent), or a dry chlorine bleach (6 percent). Of those who used bleach, 60 percent lived in rural areas, compared with 40 percent in the city. The type of fabric worn and the kind of soil found in clothing could explain why more rural than urban women used bleach. Most of the women over 25 years of age used bleach, compared with about half of the younger women.

Satisfaction

Only 5 percent of the sample was dissatisfied with the way clothing looked after laundering. Most of the women were very satisfied or at least somewhat so. Still, they reported having some problems such as broken threads, frayed material, stubborn soil, shrinkage, or loss of body. More of the younger than the older women had problems of this sort, perhaps because the young homemakers were uncertain about the best methods to use or because they had purchased clothing of lower quality.

Complaints about clothes looking gray were significantly related to occupation. Thirty-nine percent in clerical or sales positions, 29 percent in professional or related occupations, and 20 percent in blue-collar jobs expressed some dissatisfaction. Unlike blue-collar workers, women in white-collar positions probably wear more light-colored clothing, which tends to look gray if not properly laundered.

Information needs

Consumers spend considerable time and money on clothing. With a great variety of fabrics, equipment, and cleaning products available, homemakers have to make many decisions about clothing care methods. Often, however, their choices are influenced by income, age, occupation, family size, and the like. Programs to help consumers make informed decisions are clearly needed. But to be effective, these programs must first be designed to meet the special needs of varied groups.

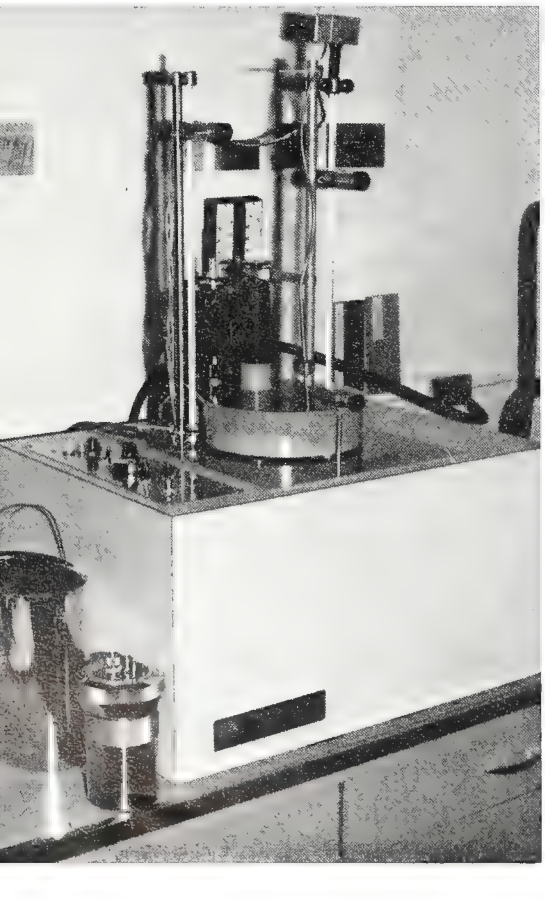
Energy Values of Juvenile Sycamores

P. CHOW, G. L. ROLFE, T. A. WHITE, and C. S. LEE

The increasing cost and decreasing availability of fossil fuels are forcing us to search for alternative sources of energy. This need has led to an investigation into the potential fuel value of woody biomass from high-yield, short-rotation trees.

Unlike fossil fuel, wood supplies are renewable. In the future wood may serve as a standby fuel for industry when oil or low sulfur coal is scarce. Someday woody biomass may even satisfy a significant part of the nation's energy requirements.

The fuel properties of matured wood harvested from natural forests have been known for a long time. But we don't know much about the energy potential of juvenile, fast-growing hardwoods raised under intensive silvicultural systems. To assess the potential, we must first determine the physical properties, heat content, and chemical make-up of young hardwoods. This article reports our progress in an ongoing study of woody biomass used for energy.



Parr 1241 oxygen-bomb calorimeter. The bomb (foreground) is placed in the water-filled bucket behind it and then into the calorimeter for explosion. (Fig. 1)

Sample trees tested

In this phase of the project we have been studying 2-year-old sycamores, which were established at 9- and 12-inch spacings during the spring of 1978. The experimental plantations are located on marginal agricultural bottomlands at Dixon Springs in southern Illinois. Other species planted at the same time under the direction of Dr. G. L. Rolfe include cottonwood, autumn olive, silver maple, black locust, and red alder. This work has been funded by the U.S. Department of Energy.

At the time of harvest early this spring, the above-ground yield of the juvenile sycamores averaged about 2 tons per acre on a dry-weight basis. In all, 38 air-dried sample trees, including branches and stems but not leaves, were sent to the Forest Science Laboratory at the university for analysis. Height of the harvested samples averaged about 4½ feet and the stump diameter 9/16 inch. Average moisture content of the air-dried trees was 8 percent (Table 1).

Samples of wood and bark from the stems, branches, and mixtures of these parts were ground to pass through 40- and 60-mesh screens in a Wiley mill. For comparison, we also included matured sycamore lumber and two samples of commercial coal, one from an Illinois Power plant, and the other from the State Geological Survey at Urbana.

To determine the gross heat from combustion of the samples, we used a new Parr 1241 oxygen-bomb calorimeter with automatic jacket control (Fig. 1). The water equivalents of these results were determined in a series of ten individual tests using benzoic acid pellets. The average energy equivalent of the calorimeter was 2,454 calories per degree Celsius.

About 1 gram of the oven-dried, pelletized wood sample was placed in the bomb, which was charged with 30 atmospheres of oxygen. Caloric value was computed from temperature observations before and after combustion. The results were calculated in calories per gram and in British thermal units per pound (Table 2). Multiplying calories per gram by 1.8 gives Btu's per pound.

After each test the interior surfaces of the bomb were rinsed with water containing the titration indicator methyl orange. Washings were titrated with 0.0725 N (normal) sodium carbonate solution for nitric acid correction. The unburned fuse wire was also measured.

Gross heat of combustion in calories per gram was calculated using the formula:

$$Hg = 1/m(Wt - e_1 - e_2 - e_3)$$

Where:

Hg = gross heat of combustion
W = energy equivalent of calorimeter in calories per degree Celsius
m = mass of sample in grams
t = net corrected temperature rise between temperature at time of firing and after combustion
e_1 = correction in calories for heat of formation of nitric acid = milliliter of 0.0725 N alkali
e_2 = correction in heat of formation of sulfuric acid = 14(sulfuric acid content) (m)
e_3 = correction in calories for heat of combustion of fuse wire = (2.3) (wire length consumed) when using nickel-chromium fuse wire

This formula is commonly used to determine the fuel value of commercial coal.

The sulfur content of each sample was measured by simply recovering the bomb washings from each caloric test. Ash content was determined after 2-gram samples had been subjected to a temperature of 600°C in a muffle furnace. Lignin and alcohol-benzene extractive contents were also determined. All procedures were done in accordance with the standard methods of the American Society for Testing and Materials.

Properties of young sycamores

The relative distribution of biomass and tree components for five samples is shown in Table 1. Bark accounted for an average 16 percent of the stem weight. Of the total above-ground weight, 93 percent was main stem and 7 percent branches.

Specific gravity of the 2-year sycamores averaged 0.64 for oven-dried weight and volume and 0.58 for oven-dried weight and air-dried volume. This value was higher than the 0.52 for the matured sycamore lumber used for comparison, and the 0.49 for sycamore wood recorded in the *Wood Handbook*, U.S. Forest Products Laboratory, Madison, Wisconsin.

Our findings indicate that the fast-grown, short-rotation juvenile sycamores contained more solid material than the matured sycamore wood on the basis of weight per unit volume. It is well known that specific gravity, or density, is the most important physical property affecting the characteristics of wood burned for fuel.

The average heat value was 7,659 Btu's per pound for the 2-year sycamores and 7,472 Btu's for the commercial sycamore wood (Table 2). Stem bark alone had a slightly higher heat value than branches and stem wood. Coal had a greater heat value

Table 1. — Average Physical Properties of 2-Year-Old, Air-Dried Sycamores[a]

Sample tree no.	Average size	Stump diameter, inches	Stem height, inches	Moisture content, pct.	Weight of stem, pct.: Bark	Weight of stem, pct.: Wood	Total weight, pct.: Main stem	Total weight, pct.: Branches	Specific gravity[b]
23	large	.692	55	8.1	18.5	81.5	92.6	7.4	.63
24	large	.696	58	8.0	15.2	84.8	93.3	6.7	.65
18	medium	.611	52	7.3	13.8	86.2	94.0	6.0	.61
19	small	.443	48	7.7	15.7	84.3	91.0	9.0	.65
29	small	.425	47	7.7	17.8	82.2	95.0	5.0	.66
Average		.573	52	7.8	16.2	83.8	93.2	6.8	.64 (.58)[c]

[a] Each value is an average for four measurements.
[b] Based on oven-dried weight and volume.
[c] Based on oven-dried weight and air-dried volume.

Table 2. — Average Fuel Properties and Chemical Analysis of 2-Year-Old Sycamore Biomass

Fuel type	Mean gross heat content[a]: Cal/g	Mean gross heat content[a]: Btu/lb	Sulfur content, pct.	Ash content, pct.	Lignin, pct.	Alcohol-benzene extractives, pct.
Stem bark	4,298	7,736	0.025	3.4	26.9	14.4
Branches	4,277	7,698	0.019	1.5	23.6	9.7
Stem wood	4,250	7,650	0.018	1.2	18.2	5.7
Whole trees	4,249	7,659	0.016	1.1	18.9	11.6
Commercial sycamore wood	4,151	7,472	0.024	0.6	. . .	. . .
Commercial coals[b]	6,747	12,145	2.210	13.5	. . .	. . .

[a] Based on air-dried condition.
[b] Coal samples were collected from the Illinois Power Co., Oakwood, Illinois, and from the State Geological Survey.

than any of the other materials tested in this study. By direct combustion, 1.6 pounds of dry, short-rotation sycamores yield about the same amount of heat as 1 pound of commercial grade coal.

Ash content of the whole tree was 1.1 percent. The percentage of ash was greater in stem bark than in stem wood, branches, and mixtures of these parts. In our experiments, mineral content in young sycamores was greater than in matured sycamore wood. Coal had an average ash content of 13.5 percent, which was 10 times greater than that of the sample trees. Coal also had the highest sulfur content, averaging 2.2 percent. In sample trees, the percentage of sulfur was negligible.

With low ash and sulfur content, the biomass of juvenile sycamores is a relatively clean fuel compared with coal. Because ash is not combustible, it stays in the furnace and tends to interfere with combustion. A significant amount of sulfur in fuel is especially undesirable because of problems with corrosion and emissions into the air.

Both lignin and extractive contents were positively correlated with heat content of the sample trees. Stem bark had more lignin and extractives than either branches or stem wood. It appears that chemical composition influences heat content.

A likely source of energy

Preliminary tests of wood fibers from 2-year, plantation-grown sycamores are promising. The heat content was somewhat greater in our young samples than in the matured wood of the same species. Because these woody biomass materials are renewable, eventually they may be preferred to certain other sources of energy.

By the end of 1980 another eight species will have been harvested. Test data and complete information will be developed in the future.

P. Chow and G. L. Rolfe are professors in the Department of Forestry; T. A. White is associate forester; and C. S. Lee is a graduate research assistant.

Soybean Damage From Combines

JOHN W. HUMMEL and MARVIN R. PAULSEN

Grain buyers, both foreign and domestic, are becoming increasingly concerned about the quality of marketed soybeans. Complaints about exported beans in particular are more frequent than in the past. Although soybeans are damaged in the market channel, some damage also occurs in the combine threshing mechanism during harvest. The development of rotary threshing equipment is an attempt to minimize this damage while increasing capacity.

In the rotary combine, one or more longitudinal rotors replace the conventional cylinder, concaves, and straw walkers for threshing and separating grain from crop material. Swirled rearward by the rotor, the material passes over concave surfaces several times, but apparently with less impact than from the action of a conventional cylinder.

This study had several objectives: (1) to compare soybean damage caused by rotary and conventional combines during harvest; (2) to determine the damage caused by the speed of the cylinder and rotor at each of three moisture levels; (3) to determine the extent of damage in relation to concave clearance; (4) to compare threshing and separating losses of the three combines tested; and (5) to compare damage from threshing with damage from conveyor augers and elevators.

Equipment tested

We tested three combines: an International Harvester 1460 Axial-Flow (single rotor), a Sperry New Holland TR-70 (double rotor), and a John Deere 7700 (conventional cylinder). All were equipped with 20-foot floating cutter-bar headers.

To allow sampling of grain, a small spring-loaded trap door was installed on the clean-grain auger of each combine. Canvas on a roller was attached immediately ahead of the rear wheels and unrolled for sampling crop material discharged from the rear of the combine. The tests were conducted in a 60-acre field of Amsoy-71 soybeans planted in 30-inch rows. Average yield was about 50 bushels per acre.

The purpose of the first of two experiments was to determine mechanical damage to soybeans as related to threshing mechanism design and speed, grain moisture content, and sampling location. In these tests bean moisture at harvest was 13.3, 12.5, and 11.6 percent. Samples for determining damage were collected at two locations: from the clean-grain auger and from the grain-tank auger. A secondary experiment for determining the effect of concave clearance on soybean damage was conducted at one moisture level.

Combine settings

In the main experiment a low, a high, and two intermediate speeds were used for each combine (Table 1). The next to the lowest speed was considered to be near the optimum for each. Samples from the clean-grain auger were used for measuring soybean damage resulting from threshing mechanism speed and design.

All three combines were operated at a ground speed of 3 mph and at the same stubble height. These settings ensured that the feed rate for all machines would be the same. Concave clearance was held constant for all test runs at each moisture level (Table 2). Fan speed was also held constant at 900 rpm for the conventional cylinder, 780 for the single and 885 for the double rotor.

An independent, licensed, grain-grading inspector tested for moisture content, test weight, and percentages of splits, damaged kernels, and foreign material. Personnel in the Agricultural Engineering Laboratory analyzed the samples for percentages of whole beans, splits, Stein breakage, and seedcoat cracks.

Effects of rotor speed

In the main experiment, the only tests significantly affected by sampling location were those for percentage of splits. Grain-tank samples from all three combines contained a greater percentage of splits than did samples from the clean-grain auger, regardless of harvest moisture and speed of the cylinder or rotor. However, the size of the percentage increase varied among combines and with cylinder or rotor speed.

Splits in samples from the clean-grain auger averaged 5.62 percent for the conventional cylinder, 1.70 for the single and 1.40 for the dou-

Table 1. — Comparison of Threshing Mechanism Speeds

Av. peripheral speed, fpm	Threshing mechanism speed, rpm: Conventional cylinder	Single rotor	Double rotor
2,360	425	375	510
2,860	525	450	610
3,350	625	525	710
3,850	725	600	810

Table 2. — Concave Clearance for Threshing Mechanisms at Three Harvest Moistures

Moisture, percent	Rear concave clearance, inches[a]: Conventional cylinder	Single rotor	Double rotor
13.3	0.19	0.75	0.81
12.5	0.31	1.25	0.81
11.6	0.56	1.50	1.00

[a] Clearance measured at the rear of the concave was one-half of the clearance at the front of the concave.

ble rotor. Average percentages from the grain tank were 6.57 for the conventional cylinder, 2.29 for the single and 2.82 for the double rotor.

With only one exception, the conventional cylinder accounted for a significantly greater percentage of splits than did either of the two rotary mechanisms at each peripheral threshing speed and moisture content. The exception was the single-rotor mechanism operating at the lowest speed and harvesting beans at 11.6 percent moisture (Table 3). It should be noted that in our laboratory tests the percentages of splits were consistently below the 10 percent maximum allowed for U.S. No. 1 soybeans (Fig. 1).

When rotor speed was decreased to the lowest setting, the threshing and separating losses were significantly greater than at the two highest speeds. (Rotary combines depend on rotor speed to produce the centrifugal force necessary for grain separation.) The conventional combine showed no significant differences at any two cylinder speeds. In general the losses, as percentage of yield, were quite small for all three threshing mechanisms: 0.23 percent for the conventional cylinder, 0.38 for the single and 0.25 for the double rotor.

Overall, these results indicate that a reduction in the percentage of splits as a result of decreasing cylinder or rotor speed may be offset by an increase in threshing and separating losses, especially for the two rotary threshing mechanisms. The increased loss as the rotor speed was decreased may have been caused by less effective grain separation at the slowest rotor speed.

Effect of concave clearance

In the secondary experiment, we found that concave clearance did not have a major effect on soybean damage. However, the effect was highly dependent on the type of threshing mechanism. For the conventional cylinder combine, neither the percentage of splits nor of foreign material differed significantly from one clearance level to the next. For the single-rotor combine, mean percentages of splits were higher at the minimum than at the other three clearance levels. Foreign material did not change significantly with concave clearance. For the double-rotor combine, splits were significantly higher at the next to the closest clearance than at any of the other clearances except at the most open.

Less damage possible

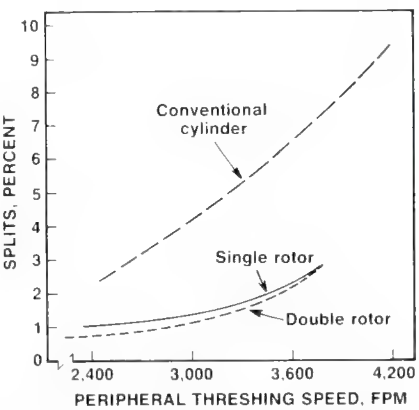
From these test results we reached several conclusions:

- Percentages of splits in Amsoy-71 soybeans were significantly greater for the conventional-cylinder than for the single-rotor or the double-rotor threshing mechanisms at similar peripheral threshing speeds. But when the combines were operated within the speed range recommended by the manufacturers, splits did not exceed the 10-percent limit allowed for U.S. No. 1 soybeans.
- Percentages of splits increased as the peripheral threshing speed of all three combines was increased, but the rotary mechanisms produced a smaller increase in splits than did the conventional cylinder.
- Design improvements are needed in the augers and elevators that convey the beans from the clean-grain auger to the grain tank. Percentage increases in splits due to conveying averaged 0.96 for the conventional cylinder, 0.60 for the single and 1.42 for the double rotor.
- Mean threshing and separating losses decreased as rotary threshing speed increased. Mean losses ranged from 0.27 to 0.90 bushel per acre.
- Percentages of splits were usually affected less by increasing the concave clearance than by changes in cylinder or rotor speed.
- Soybean susceptibility to breakage, as determined by the Stein breakage test, did not differ significantly among threshing mechanisms or cylinder and rotor speeds. The same was true for the percentage of seedcoat cracks and for other grading factors such as test weight and percentage of damaged kernels and foreign material.

Table 3. — Percentage of Splits in Clean-Grain Auger Samples Compared for Three Threshing Mechanisms at Various Speeds[a]

Av. peripheral speed, fpm	Conventional cylinder	Single rotor	Double rotor
	Splits in samples, percent[b]		
	13.3 percent moisture		
2,360	2.48[a]	0.91 [b]	0.66 [b]
2,860	3.68[a]	1.24 [b]	0.68 [b]
3,350	6.22[a]	1.53 [b]	1.33 [b]
3,850	7.74[a]	3.01 [b]	2.30 [b]
	12.5 percent moisture		
2,360	2.28[a]	0.84 [b]	0.81 [b]
2,860	4.18[a]	1.62 [b]	1.00 [b]
3,350	7.60[a]	1.47 [b]	1.07 [b]
3,850	10.86[a]	3.01 [b]	2.30 [b]
	11.6 percent moisture		
2,360	2.59[a]	1.19[ab]	0.87 [b]
2,860	4.22[a]	1.22 [b]	0.95 [b]
3,350	6.60[a]	1.77 [b]	1.40 [b]
3,850	8.92[a]	3.60 [b]	2.54 [b]

[a] Data based on means of three replications.
[b] Numbers with the same letters within rows at each moisture level do not differ significantly at the 5-percent level based on the LSD test for differences between means.



Effect of peripheral threshing speed on percentage of splits in clean-grain auger samples. Results were averaged from three harvest moisture levels of 13.3, 12.5, and 11.6 percent. (Fig. 1)

John W. Hummel is an agricultural engineer with the USDA Science and Education Administration, Agricultural Research, at Urbana; Marvin R. Paulsen is assistant professor of agricultural engineering. This article is based on thesis research conducted by R. S. Newbery. Financial aid was supplied in part by the Ill. Crop Improvement Association. Deere and Co., International Harvester Co., and Sperry New Holland provided technical aid; the latter two companies provided equipment as well. Mention of trade names does not constitute a guarantee or imply approval of a product to the exclusion of other suitable products.

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FARM BUSINESS TRENDS

MAJOR TRENDS in Illinois agriculture are expected to continue, according to the preliminary report of the 1978 Census of Agriculture. Farm numbers are decreasing, farm size is increasing, and operations are becoming more specialized.

Between 1974 and 1978 the number of farms declined by 1,279 — from 111,049 to 109,770. In the 1978 census the definition of a farm for statistical purposes was "any place from which $1,000 or more of agricultural products were sold, or normally would have been sold during the census year." For the 1959, 1964, and 1969 censuses, and for the 1974 preliminary county reports, a farm was defined as "any place with less than 10 acres from which $250 or more of agricultural products were sold or normally would have been sold during the census year, or any place of 10 acres or more from which $50.00 or more of agricultural products were sold or normally would have been sold during the census year." Had this definition been used in the current census, farms would have numbered 121,192 in 1978, an increase of 5,238 over 1974.

Farms with $2,500 or more in sales numbered 96,559 in 1978, down from 97,703 in 1974, whereas the acreage per farm went up slightly during this period. Overall, the average size of farms with this volume of sales increased from 290 to 303 acres. Farms of 500 acres or more totaled 17,266 or 15.7 percent of all farms in 1978, up from 15,193 or 13.7 percent of the total in 1974.

Although the use of irrigation is still not widespread, the number of farms having a system and the acreage irrigated about doubled in four years, from 650 to 1,254 farms and from 53,777 to 131,322 acres.

In all categories of livestock, fewer farms were selling any given species in 1978 than in 1974. But between the beginning and the end of this period there was an actual increase in the number of cattle and hogs sold. In 1974, 51,804 farms reported selling cattle, but by 1978 this number was down to 46,793. The number of farms selling hogs in 1974 was 35,118 versus 30,274 in 1978. During the same four-year period the number of farms selling sheep and lambs dropped from 6,811 to 5,036.

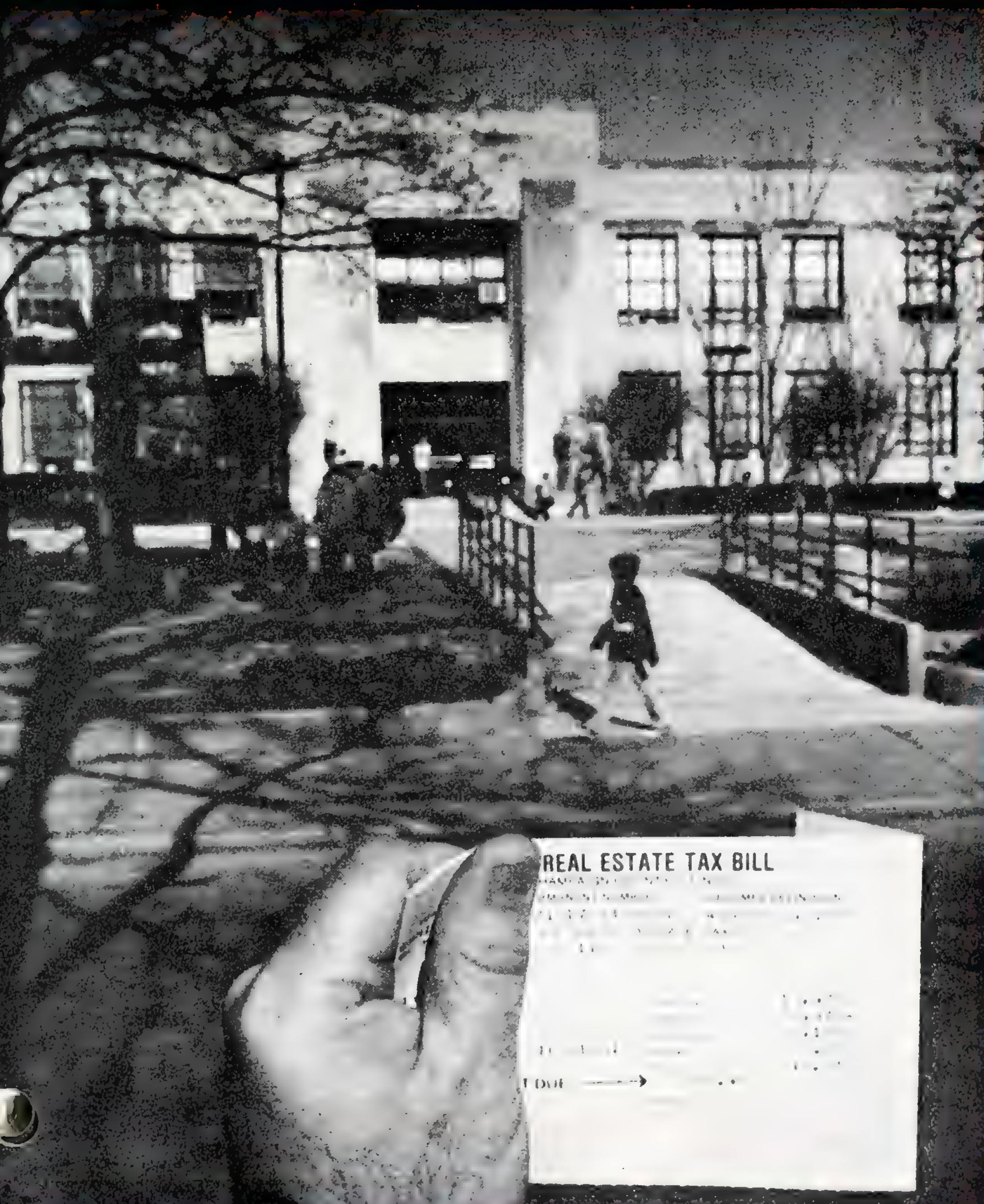
The Census of Agriculture, taken by the U.S. Department of Commerce, Bureau of Census, serves as a bench mark or check for various agricultural data series. Begun in 1840, the agricultural census was taken every five years from 1920 until 1974. However, the current census was taken after an interval of only four years. Reducing the elapsed time is one step in a program to bring the agricultural census in line with census data collected for other segments of the economy. As in recent censuses, the 1978 Census of Agriculture was conducted primarily by mail. Before 1969 all census information was gathered by direct interview.

The 1978 Census of Agriculture provides data on many items other than those reported here, such as land use, farm sales, livestock organization, tenure, production expenses, and inventory of equipment. Census information is of great importance to those segments of the agricultural industry that provide goods and services to production agriculture. Available for both the state and individual counties, this information can be used in various ways for making plans related to agriculture. — *M. B. Kirtley, Extension economist in livestock marketing.*

Winter, 1981

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station



IN THIS ISSUE

Property taxes help pay for public education, but state aid also pays a big chunk of the bill (page 12).

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE Volume 23, Number 1

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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(Cover picture by Paul Hixson)

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AGRICULTURE AND GOVERNMENT

JOHN R. BLOCK, former Director of the Illinois Department of Agriculture, has recently been appointed Secretary of Agriculture. Some readers may think it unusual that we should refer to this appointment in *Illinois Research*. Let me share with you the reason for doing so.

A view is evolving about the relationship between the political and the research processes. According to this view, many desirable changes are needed in agriculture throughout Illinois and across the nation. But these changes can be accomplished with the least delay and in the best way possible only if these two processes are better coordinated.

The mixing of political decisions and research decisions is not the question. The real question rests in what we perceive to be the opportunities in agriculture and how to bring about the desired changes by blending political and research decisions into well coordinated, well understood plans. To make progress the broad problems and opportunities in agriculture require the combined efforts of the best minds in many organizations, including government and the university.

John Block will need our help, as we will need his help and that of people who operate farms and farm businesses. Together we can then plan programs and set in motion the changes that are in the best interests of the agricultural community and all citizens.

It makes sense to review critically how agricultural research and government might attempt to recognize and solve problems and to open up new opportunities in a more efficient way. In the broad view, the people in government and at land-grant universities are public servants all. And doesn't that mean that we should pursue the changes needed in agriculture in a more unified way? — *R. G. Cragle*

Fungi Promote Growth of Vegetables

W. E. SPLITTSTOESSER

FUNGI EXIST in many forms, some of which are harmful and others beneficial. Certain helpful kinds are commonly intertwined with plant roots. Under a microscope, what may appear to be very fine root hairs are in reality hyphae, the threadlike extensions of a fungus. The word "mycorrhiza" (from *myco* referring to fungus and *rhiza* to roots) is used to describe this association.

Mycorrhizae are found in almost all vegetable plants. A notable exception is the Cruciferae or mustard family, which includes cabbage, horseradish, radish, and turnip, among others. The fungi that infect vegetable roots are endotrophic, that is, the hyphae or hyphal strands actually penetrate the roots and branch out between cells (Fig. 1). In this association, both roots and hyphae are in contact with the soil.

The arrangement is advantageous to fungus and plant alike. The fungus produces mannitol, a sugar alcohol that inhibits the plant enzymes from making insoluble carbohydrate. Instead, the carbohydrate stays soluble, and about 10 percent of it moves into the fungus. In turn, the fungus supplies the plant with several nutrients, notably phosphorus.

Absorption of phosphorus

Roots absorb some minerals more readily than others. Potassium, nitrate, and sulfate, which are highly mobile, are easily absorbed from the soil, and therefore the plant can obtain enough of them through a few feeder roots. But copper, zinc, and especially phosphate are only slightly soluble and consequently not very mobile. The amount absorbed depends on the number of feeder roots and the presence of mycorrhizal fungi.

Plant species differ in the number of roots and root hairs they contain. Cereals and grasses, for example, have extensive root systems covering a large volume of soil. These plants usually do not respond well to infection by mycorrhizal fungi. However, plants such as leeks, which have few feeder roots, grow significantly better when infected.

One of the main benefits of mycorrhizae is that the growth of hyphae into the soil increases the volume that can be explored for nutrients. A second major benefit is that the fungi are ten times more efficient than plant roots in absorbing these nutrients.

All mycorrhizal fungi seem to be equally efficient in absorbing nutrients, transporting them to the plant, and increasing plant growth. However, growth is influenced more by soil type, temperature, and pH than by the type of fungi. In addition, the fungus-soil interaction influences plant growth more than does the fungus-plant interaction.

Roots have a threshold value below which they cannot absorb phosphorus. Mycorrhizal fungi have a still lower threshold and are therefore able to absorb phosphorus when soil concentrations are too low for absorption through the roots. Thus, growers can fertilize with rock phosphate, a form of phosphorus that dissolves slowly. The fungi do not dissolve the phosphorus, but absorb it as it becomes available.

Plants with mycorrhizae utilize phosphorus more efficiently than do plants without the fungus-root association. But there is one drawback: soils that are already low in phosphorus will become very deficient after two or three crops of plants with mycorrhizae.

When phosphorus levels in the soil are high, most plants fail to become infected. From one plant species to another, however, large differences occur in micorrhizal uptake of phosphorus. One way to look at the difference is to determine the amount of applied phosphorus that plants need in low phosphorus soils when there are no mycorrhizal fungi present. As the list indicates, some species need much more than others:

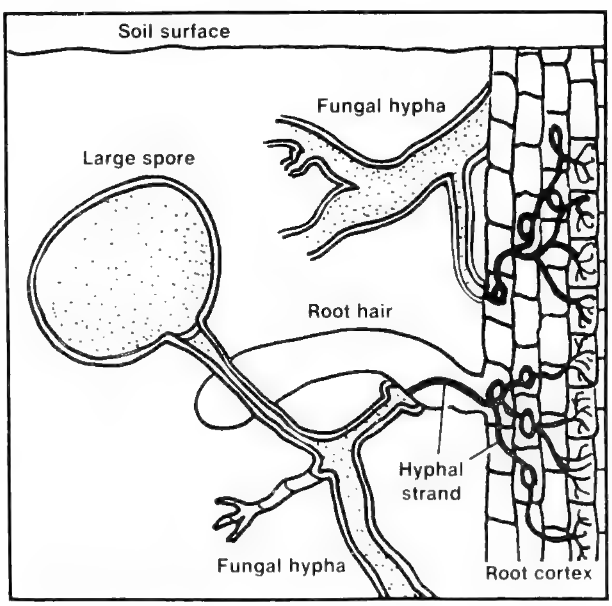


Diagram of mycorrhiza, the association between a fungus and a plant root. Entering through root hairs or the epidermis, the fungus penetrates only a few outer layers of root cells. This diagram is not to scale: the fungus is much smaller than root hairs. (Fig. 1)

Plant	Kg/ha
rye	30
corn, wheat, barley	60
onion, leek	100
strawberry	130
cassava	160
sour orange	560

Occurrence of mycorrhizae

Although these fungi can be found in nearly all soils worldwide, there may be little plant infection during a cool spring or because of low fungal populations. If such conditions prevail when phosphorus needs are greatest, plant growth may be poor.

Various agricultural practices influence the number of fungi. For instance, soil sterilization, which is common in California, kills pathogenic fungi, weed seeds, and nematodes, but it reduces the population of mycorrhizal fungi as well. Their numbers may also decrease in the absence of suitable host plants during fallow periods. Yet, even after twenty years of continuous fallow in some fields in England, the fungi were still present and became active when host plants were grown.

Mycorrhizae benefit plants in many ways. Compared with noninfected plants, those that are infected are generally healthier and better able to withstand the shock of transplanting. Plant roots also regenerate faster after periods of drought. If nematodes or cultivation have damaged the roots, the undamaged part of the mycorrhizal root system can compensate for some of the loss. In most cases, the infected root is resistant to pathogenic fungi. Because the hyphae penetrate decomposing organic matter such as corn or bean trash, they are able to compete with other soil microorganisms for the released nutrients.

At present, these fungi cannot be grown in pure culture and are unavailable commercially. There are alternative ways to introduce them, however. Vegetables can be started in infected soil and then transplanted into a noninfected field, or the soil and roots from infected plants can be used. When cut up, the mycorrhizae, along with the soil, can be used as an inoculum in sterilized areas.

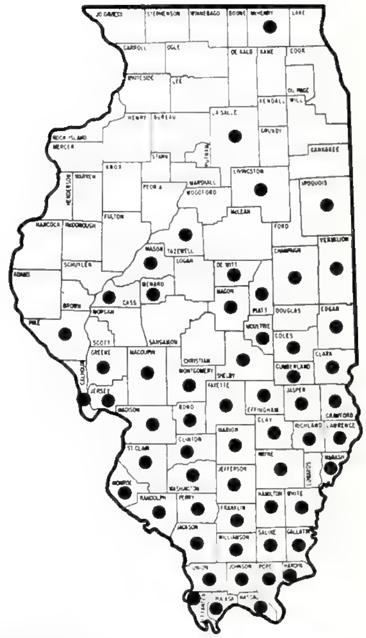
In many temperate regions, the soils have adequate levels of phosphorus or are regularly fertilized; therefore mycorrhizal fungi have little effect. However, with increasing cost and potential shortages of phosphorus, mycorrhizae will undoubtedly become more important someday.

W. E. Splittstoesser is professor of plant physiology in the Department of Horticulture.

Update:

Soybean Cyst Nematode

D. I. EDWARDS and G. R. NOEL



Distribution of soybean cyst nematode in Illinois, 1980. (Fig. 1)

THE SOYBEAN CYST NEMATODE, *Heterodera glycines,* is well established as a major soybean pathogen in Illinois. The first infestation was found on a 20-acre field in Pulaski County in 1959. Since then, infestations have been detected in a total of 58 counties from the southern tip of the state to McHenry County in the north (Fig. 1).

Detection was greatly aided by an aerial survey of 65 counties in 1977, 1978, and 1979. As a result of the survey, we found 16 infested counties not identified before.

Losses

Yield losses due to soybean cyst nematode (SCN) are difficult to verify because insects, weeds, climatic conditions, soil fertility, and other pathogens may also affect yields. However, 1979 SCN losses for Illinois were conservatively estimated at 12 million bushels. The estimate was based on data from nematicide research plots, performance of resistant and susceptible varieties, growers' production figures, and field observations of research and Extension personnel. Most of the loss occurred in the southern third of the state. SCN has been established there longer than elsewhere in Illinois, and infestations have become well established on hundreds of thousands of acres.

Races

At least four races of soybean cyst nematode have been reported in the United States. According to race tests performed by research and Extension personnel, race 3 occurs on about 75 percent and race 4 on 25 percent of the infested Illinois acreage. Races 1 and 2 have not been found in the state.

Occasionally, workers encounter field populations of SCN that do not conform to the present race scheme. This situation strongly indicates that other races exist. But before new

designations can be made, information about SCN development on various soybean hosts must be gathered and morphological differences between nematode populations determined.

Control

Resistant varieties. Progress has been made in developing cultivars resistant to soybean cyst nematode. Resistance to races 1 and 3 has been derived from the black-seeded cultivar Peking and incorporated into eight public cultivars. Three of these, Custer and Franklin (maturity group IV) and Forrest (V), are grown in southern Illinois (Table 1). Because of Franklin's superior agronomic characters, it will eventually replace Custer in that part of the state. Forrest is now grown in the four southern tiers of counties.

In 1977 Bedford, the first cultivar resistant to race 4, was released in the southern United States. The resistance was obtained from PI 88788, which was crossed with Forrest. Like Forrest, Bedford is in maturity group V.

Because SCN infestations occur in central and northern Illinois, geneticists are developing resistant varieties in maturity groups II and III. This work is being carried out by the U.S. Department of Agriculture Science and Education Administration in cooperation with the Illinois and Missouri Agricultural Experiment Stations. In 1980 these agencies announced the germplasm release of the soybean line L77-994 (maturity group III), which is resistant to races 1, 3, and 4. Resistant cultivars that mature early should be forthcoming in two or three years.

Chemical control. In areas of Illinois where resistant varieties are unavailable, growers may want to consider using nematicides for the control of soybean cyst nematode. At present the only compounds registered for use against SCN are aldicarb 15G, ethoprop 10G, and phenamiphos 15G and 3EC. Although all three nematicides offer some degree of control, aldicarb 15G applied at 13.5 to 20 pounds of formulation per acre has provided the most consistent yield response (Table 2). These nematicides have not been used extensively in Illinois because of their high cost and the ability of resistant varieties to produce yields as large as those from soybeans treated with the most effective nematicide.

Rotation. Rotation has proven to be an effective control measure for many diseases, SCN included. However, the time interval between soybean crops depends on infestation levels. Growing soybeans every other year, for example, will cause SCN levels to increase, although not as rapidly as with continuous soybeans.

To reduce SCN populations, a nonhost crop should be planted for two or preferably three years between soybean crops. Since the nematode varies genetically, infested fields may contain more than one race. The use of a sound rotation will minimize the development of a race to which a variety is not resistant and prolong the useful life of resistant varieties.

Outlook

If the current trend in the intensification of soybean production continues, we can safely predict that SCN problems will increase. Rotation combined with proper fertility and pH levels should be the foundation upon which SCN management programs are built.

Growers cannot depend completely on nematicides for SCN control, and development of a variety resistant to new races requires about ten years. Sources of germplasm with resistance to new races of SCN are unknown at this time. If we are to manage the soybean cyst nematode adequately, the search for new and higher levels of genetic resistance must be intensified and methods developed for increasing the efficacy of nematicides.

D. I. Edwards is associate professor and USDA Science and Education Administration (SEA) plant pathologist, and G. R. Noel is assistant professor and USDA-SEA plant pathologist in the Department of Plant Pathology.

Table 1. — Yields of Varieties Resistant and Susceptible to Soybean Cyst Nematode Race 3, Franklin Co., Ill., 1977

Variety (maturity group)	SCN status	Yield, bu/A
Forrest (V)	resistant	45.5
Franklin (IV)	resistant	45.1
Custer (IV)	resistant	38.0
Essex (V)	susceptible	27.7
Cutler-71 (IV)	susceptible	24.1

Table 2. — Field Evaluations of Nematicides Registered for Control of Soybean Cyst Nematode, Illinois

Chemical and test site by county	Product, lb/A[b]	Years tested	Yield, bu/A[a] Treated	Yield, bu/A[a] Untreated
ethoprop 10G				
Franklin	20.0	1968	10.3	12.9
	30.0	1976	36.3	32.0
phenamiphos 15G				
Franklin	7.3	1977, 1978	22.6	20.9
Vermilion	7.3	1977, 1978	41.9	37.2
Franklin	14.5	1975-1979	30.7	27.7
Vermilion	14.5	1977-1979	38.5	35.0
Franklin	29.0	1974, 1975, 1979	30.8	25.5
Vermilion	29.0	1979	33.5	30.7
aldicarb 15G				
Franklin	10.0	1978, 1979	30.0	26.6
Vermilion	10.0	1978, 1979	36.4	31.9
Franklin	13.5	1977-1979	32.5	26.3
Vermilion	13.3	1978, 1979	40.3	31.9
Franklin	20.0	1976, 1977, 1979	39.1	31.3
Vermilion	20.0	1977, 1979	43.1	36.0

[a] Average or actual yields obtained during the various test years.
[b] Applied in 7- to 14-inch band at planting and incorporated 2 to 4 inches deep.

Cultural Practices for Short-Statured Soybeans

J. S. BEAVER and R. R. JOHNSON

DETERMINATE SOYBEANS have traditionally been grown in the southeastern United States. During the past few years, however, they have become available to northern growers, who are accustomed to raising indeterminate varieties. Farmers use a wide range of cultural practices, some of which may not be entirely suited to short-statured, determinate beans. Our research attempted to identify those practices that are most appropriate for growing determinate varieties in the Midwest.

Differences in plant types

Determinate and indeterminate varieties differ in several important ways. Determinate soybeans begin flowering simultaneously in both the upper and lower parts of the plant. In the indeterminates, flowering starts at the base of the plant and moves upward. Although determinate varieties flower over a shorter period of time than do indeterminates, the difference in duration of the flowering period is less than might be expected. For example, flowering in the determinate variety Elf lasts 18 to 25 days, and in the indeterminate variety Williams, 25 to 45 days.

Another important difference is that determinate plants do not get appreciably taller after flowering begins. As a result, they are often only half to two-thirds as tall as the conventional, indeterminate plants of similar maturity group, which continue to grow taller during the first few weeks of flowering. The shorter stature of determinates, combined with a thicker stem, produces good resistance to lodging.

These two characteristics — short stature and lodging resistance — suggested to us that the determinate varieties now available in Illinois might have a better yield response to narrow row widths than do the indeterminate varieties. Also, a study of planting dates seemed useful because no information was available for the performance of determinate varieties planted after early June.

In experiments from 1977 to 1979 at Urbana, two determinate and two indeterminate varieties were grown at five planting dates from early May to early July. At each date the varieties were tested at row widths of 32, 20, and 8 inches. The indeterminates were Beeson (maturity group II) and Williams (III); the determinates were Gnome (II) and Elf (III).

Row width

The yield responses to decreasing row width were similar when averaged for all years, planting dates, and varieties (Table 1). As row width was decreased from 32 to 20 inches, yields increased an average of 3.8 bushels per acre (8.7 percent). But when the widths were decreased from 20 to 8 inches, the yields remained virtually the same. On the average, the determinate varieties lodged less than did the indeterminates. However, all varieties lodged more at the 32-inch than at the 20-inch or 8-inch row widths.

A similar study was conducted during 1977 and 1978 at the Brownstown Research Center about 100 miles to the southwest of Urbana. At this location soil conditions and precipitation patterns are such that soybeans are likely to undergo drought stress one or more times during the growing season. As expected, these patterns recurred in 1977 and 1978, resulting in a mean yield of only 26.7 bushels per acre (Table 2).

Table 1. — Soybean Yields at Three Row Spacings, Urbana

Variety	Row spacing, inches: 32	20	8	Mean
	Yield, bu/A[a]			
Gnome	45.2[b]	50.1	49.2	48.2
Elf	43.7	46.9	47.4	46.1
Beeson	43.3	48.6	47.6	46.5
Williams	42.8	44.9	44.6	44.1
Mean	43.8	47.6	47.2	46.2

[a] Yields were averaged for five planting dates and three years.
[b] The LSD at the 5-percent level, used to compare row-spacing means of a particular variety, was 1.3 bushels per acre.

Table 2. — Soybean Yields at Three Row Spacings, Brownstown

Variety	Row spacing, inches: 32	20	8	Mean
	Yield, but/A[a]			
Gnome	27.5[b]	29.0	29.0	28.5
Elf	27.5	30.3	27.7	28.5
Beeson[c]	19.5	20.1	20.4	20.0
Williams	29.3	29.9	30.2	29.8
Mean	26.0	27.3	26.8	26.7

[a] Yields were averaged for three planting dates and two years.
[b] The LSD at the 5-percent level, used to compare row-spacing means of a particular variety, was 1.8 bushels per acre.
[c] Beeson did not yield well because it proved poorly adapted at Brownstown.

J. S. Beaver is a research associate, and R. R. Johnson was formerly an associate professor in the Department of Agronomy.

Even though the yield response to decreased row widths was less at Brownstown than at Urbana, the trends at both locations were similar. Narrowing the rows from 32 to 20 inches increased yields by an average of 5 percent at Brownstown, whereas yields at the 20-inch and the 8-inch widths were about the same. Thus to maximize yields, both determinate and indeterminate soybeans should probably be grown at row widths of 20 inches or less.

Planting date

Among the three variables researched, planting date contributed most to yield differences. As planting date was delayed from early May through early July, yields at Urbana declined an average of 33 percent (Table 3). However, the response pattern was somewhat different for the two plant types. The yields of Beeson and Williams decreased steadily from the earliest planting date through the latest. In contrast, the yields of Elf and Gnome showed little variation for the first three planting dates, but then declined markedly with the last two dates.

Plant height and lodging patterns were similarly affected by planting time. With each successive planting date, the height of Beeson and Williams decreased, whereas Elf and Gnome attained their greatest height with the early June planting. According to lodging scores averaged for all planting dates, Elf and Gnome lodged less than Beeson or Williams. However, the determinate varieties tended to lodge more and the indeterminates less with delayed planting. Consequently, both types when planted after mid-June had similar lodging scores.

Because of potential harvest losses, height of the lowest pods should be taken into account. The lowest pods of the determinate varieties planted after mid-June or in the drought-prone soils at Brownstown were close enough to the soil surface (less than 4 inches) to cause concern about excessive losses at harvest. As a rule, Elf and Gnome should stand 20 inches or more for pods to be at least 4 inches from the ground.

Seeding rate

In 1977 and 1978 at Urbana, Elf was sown at 140,000, 200,000, and 260,000 seeds per acre at row widths of 30 and 8 inches. Yields averaged 1.4 bushels per acre more for the 8-inch than for the 30-inch width (Table 4). Seeding rate, on the other hand, had no significant effect on yield. As seeding increased from the lowest to the highest rate, fewer plants survived at either width.

A similar experiment was conducted at Carbondale in 1978, but a severe drought during the growing season greatly reduced yields. However, results from both the Carbondale and the Urbana studies indicate that short determinate soybeans can produce similar yields from dissimilar seeding rates.

A rate of 140,000 to 160,000 seeds per acre is normally recommended for tall indeterminate varieties. Short determinate varieties yield well in this range, but can also tolerate a higher seeding rate without developing the lodging problems often associated with higher rates for indeterminate varieties.

Summary

Both the short determinate and the tall indeterminate varieties produced their maximum yields at row widths of 20 inches or less. Yields from the indeterminate types decreased steadily as planting was delayed past mid-May. In contrast, the yields of the determinate varieties did not decrease significantly until planting was delayed after early June.

The short-statured determinate varieties of soybeans currently available to Corn-Belt farmers are best adapted to soils that are capable of producing average yields of more than 40 bushels per acre. In these more productive soils the determinate varieties usually attain a height of at least 20 inches, which is tall enough so that pods are not too close to the ground. A seeding rate of 180,000 to 200,000 seeds per acre appears sufficient to maximize yields and reduce potential losses due to low basal pod height.

Information from this research should be useful to farmers and Extension personnel. The findings should also give geneticists some insight into ways of further improving determinate soybean varieties.

Table 3. — Soybean Yields for Five Planting Dates, Urbana

Variety	Average planting date					
	May 13	May 23	June 4	June 18	July 6	Mean
	Yield, bu/A[a]					
Gnome	50.7[b]	54.0	53.5	45.7	37.2	48.2
Elf	51.0	53.4	50.6	44.5	31.1	46.1
Beeson	51.1	50.4	49.4	45.2	36.4	46.5
Williams	50.9	49.2	46.8	41.2	32.4	44.1
Mean	50.9	51.8	50.1	44.2	34.3	46.2

[a] Yields were averaged for three row spacings and three years.
[b] The LSD at the 5-percent level, used to compare planting-date means of a particular variety, was 3.3 bushels per acre.

Table 4. — Final Stands and Yields of Elf Grown at Two Row Spacings and Three Seeding Rates

Seeding rate/A	Final stand 30" rows	Final stand 8" rows	Yield 30" rows	Yield 8" rows
	1,000 plants/A[a]		*bu/A*[a]	
Urbana				
140,000	96	121	50.4	50.7
200,000	120	154	49.4	51.3
260,000	156	196	48.3	50.4
Carbondale				
140,000	120	133	12.5	9.8
200,000	157	178	10.7	9.2
260,000	194	192	12.5	10.7

[a] Averages for two years at Urbana and one year at Carbondale.

Water-Blanket Greenhouses: The Economics of Using Waste Heat

SHERYL S. LAZARUS, JOHN B. BRADEN, and PAUL N. WALKER

IN 1978 ILLINOIS had 7.9 million square feet of greenhouse space. Heating costs, which have risen rapidly in recent years, are a major operating expense for these greenhouses. Since 1978 the price of energy has increased at an average annual rate of 16.6 percent, while the average annual wholesale price of the main crops, potted and bedding plants, has increased only 4.9 percent.

Waste heat

Electric power companies produce large amounts of waste heat that is usually dissipated in cooling towers or cooling lakes. If commercial greenhouses could use some of the heat, a major part of their energy requirement might be satisfied. To test the feasibility of tapping into this energy source, researchers at the University of Illinois have developed a system in which heated water from a power plant is pumped to the ridge of a greenhouse. The water is allowed to flow uniformly over the outside surface, thus heating and insulating the facility. The so-called water-blanket system, combined with conventional space heating, is intended to reduce overall heating costs.

An experimental greenhouse using the system has been constructed in Randolph County at the Baldwin Power Plant of the Illinois Power Company (Fig. 1). The Baldwin Plant, capable of generating 1,800 megawatts of electricity, has a 2,000-acre cooling lake. Engineering studies of this greenhouse and a similar one in Vermilion County have shown that the water-blanket system is technically feasible (see *Illinois Research*, Spring, 1978). In the present study we examined the system to see if it is economically feasible as well.

Sheryl S. Lazarus is agricultural economist and John B. Braden is assistant professor in the Department of Agricultural Economics; Paul N. Walker is associate professor in the Department of Agricultural Engineering.

Simulated heat requirements

A computer simulation model was used to obtain the heating and cooling requirements for greenhouses heated by conventional means and by the new water-blanket system. The weather segment of the model used historical weather data for Randolph County to simulate hourly temperatures, humidity, wind velocity, and sky conditions for a typical year. From this information we derived the heat requirements for a one-acre glass greenhouse having a minimum night temperature of 60°F and a minimum day temperature of 65°F. The model assumes a water temperature equal to the average monthly water temperatures at the Baldwin Power Plant (Table 1).

For a greenhouse using only natural gas, the model predicts an annual heat requirement of 63,243 therms. The electricity used for temperature control is 19,431 kilowatt-hours. (One therm contains as much energy as 29.3 kilowatt-hours of electricity.) For a water-blanket greenhouse, the annual natural gas use is 24,762 therms for heating and 100,490 kilowatt-hours for electricity. More electricity is required to operate a water-blanket system, because electric pumps must raise the heated water to the ridge of the greenhouse.

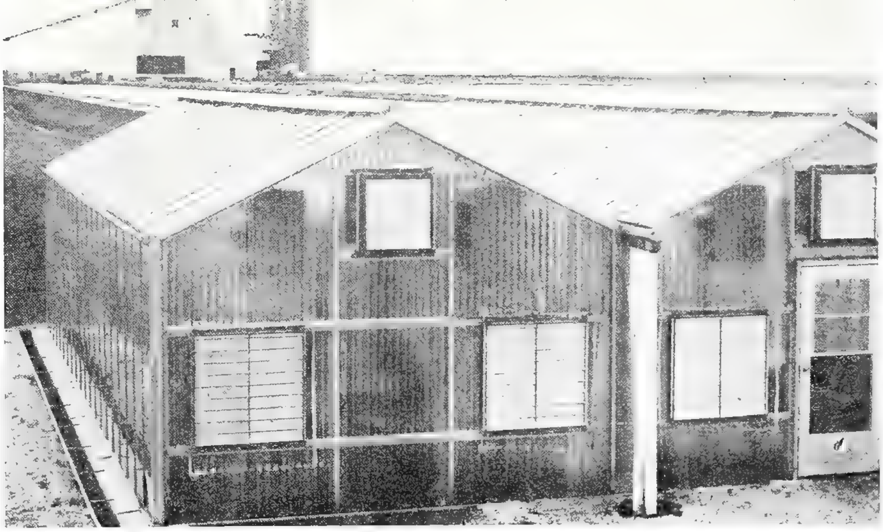
As indicated in Table 1, 55.9 percent less energy is needed to heat a water-blanket greenhouse than one with a conventional heating system. It should be pointed out, however, that the Baldwin Plant has waste-water temperatures that are lower than those of most other power plants in the nation. If the water were 5°F warmer on the average than at Baldwin, the net energy savings provided by the water-blanket system would equal 72.7 percent. Although the water-blanket system does not provide all of the heat required, particularly in the coldest months, it does provide substantial savings.

Economic analysis

The economic implications of the water-blanket system were explored through a present value analysis. Assuming 1980 prices, we compared the costs of erecting and operating a conventional greenhouse with similar costs for a unit equipped with the water-blanket system. In the model, conventional heat with natural gas was assumed necessary for both systems, the natural gas being used as a backup for the waste-water heat. The water-blanket system reduces natural gas costs in each year that the greenhouse is used, but at the expense of added capital investment, maintenance, and electricity.

Table 1. — Percent Energy Saved by Water-Blanket Greenhouse Compared With Conventionally Heated Greenhouse

	Water temp. at Baldwin		Water 5°F warmer	
	Av. water temp.	Savings, water-blanket	Av. water temp.	Savings, water-blanket
	°F	pct.	°F	pct.
Jan.	55	27.3	60	49.6
Feb.	56	32.2	61	53.4
Mar.	65	72.0	70	89.3
Apr.	80	97.2	85	97.6
Oct.	85	97.1	90	97.3
Nov.	68	84.3	73	94.8
Dec.	62	54.8	67	77.3
Av. annual savings ...	..	55.9	..	72.7



Water-blanket greenhouse at Baldwin Power Plant. Heated water is pumped from the power plant to the ridge of the greenhouse and then returned to the cooling lake, upper right. (Fig. 1)

Table 2. — Present Value Analysis of Fuel Savings and Added Costs of One-Acre Greenhouse Heated With Water-Blanket System

	Present value of savings		Present value of added costs					Present value of savings and added costs
Year	Fuel	Investment credit	Electricity	Principal payment	Interest payment	Down payment	Repairs	
1.......	$11,450	$4,200	$ 1,763	$ 413	$ 3,568	$8,400	$ 4,088	$—2,582
2.......	11,653	...	1,794	409	3,114	...	3,980	2,356
3.......	11,859	...	1,826	405	2,712	...	3,870	3,046
4.......	12,069	...	1,858	402	2,357	...	3,771	3,681
5.......	12,283	...	1,891	398	2,043	...	3,671	4,280
10.......	13,409	...	2,064	381	795	...	3,209	6,960
15.......	14,638	...	2,253	364	355	...	2,805	8,861
20.......	15,980	...	2,460	349	42	...	2,452	10,677
20-year total[a]	$271,922	$4,200	$41,860	$7,595	$24,004	$8,400	$64,091	$130,172

[a] The totals are for all twenty years, not just for the selected years shown in the table.

Present value analysis, which finds the current value of a sum of money to be received in the future, converts streams of expenditures for equipment and fuels to single figures that can be compared. A dollar that one now has is worth more than a dollar received sometime in the future because, at the future time, one would have the original dollar plus returns that it has earned.

We assumed that prices for natural gas and electricity would rise at an annual rate of 15 percent, or slightly less than the 16.6 percent average inflation rate for energy in the past three years. Prices for natural gas and electricity were taken from utility industry schedules for small commercial customers; the rate varies with the amount of fuel used. The time value of money was assumed to be 13 percent.

For the one-acre greenhouse the system cost $42,000, or $1 per square foot. A 20-percent down payment was assumed for the loan to purchase the system. The interest rate for the loan was 12 percent, and the loan matured in 20 years, which also was assumed to be the life of the system. The investment tax credit was 10 percent. Repair expenses for the first year were 10 percent of the original cost of the system, rising thereafter at 10 percent per year. The structure was assumed to be located on leased land. Aside from the investment tax credit, our analysis used pre-income tax values, since the tax rate would vary with the amount of net revenues.

The present value of natural gas savings for the water-blanket greenhouse is $271,922 (Table 2); the investment credit savings is $4,200. Expenses over and above those for a conventionally heated greenhouse are: electricity, $41,860; down payment, $8,400; interest payment, $24,004; principal, $7,595; and repair, $64,091. The difference between the present values of the savings and the added expenses is $130,172, or $2.99 per square foot of greenhouse space.

The savings would be even greater if the average monthly water temperature were 5°F warmer than the temperature at the Baldwin Power Plant. Relative to the conventionally heated greenhouse, the present value of the decreased fuel expenses would be $346,894. Added expense of electricity would be $40,144. Other added expenses would not change for different water temperatures. Hence, the present value of the net savings would be $206,859, or $4.74 per square foot.

Significant savings possible

Our preliminary economic analysis shows that substantial savings are possible in Illinois with the water-blanket system of heating greenhouses. However, ownership arrangements for such greenhouses next to a power plant are likely to involve leasing or renting land, and the utility company may charge a fee for the heated water. Also, locating greenhouses at a power plant may put them farther from markets, resulting in added transportation costs. The savings reported here represent the value of the maximum amount that could be spent for added land, waste water, and transportation to adopt the water-blanket system.

Further analyses will be done to see how the economic feasibility of this system is affected by different assumptions about the inflation rate, waste-water temperatures, weather conditions, and greenhouse structural characteristics. Our research will also be expanded to see how much energy could be saved on regional and national levels if newly constructed greenhouses were to use the water-blanket system.

<u>Survey:</u>

Horticultural Pesticides

H. J. HOPEN, M. C. CARBONNEAU, D. J. WILLIAMS, and D. B. MEADOR

Horticultural products such as vegetables, fruits, and herbs make up a significant part of the American diet. In addition, turf, flowers, landscape plants, and ornamental trees contribute to an aesthetic environment. Annually these crops account for at least $200 million of farm income in Illinois.

Pesticides are important to the production of commercial horticultural crops, but obtaining clearance is a big problem. In 1972 hundreds of minor uses for pesticides were declared legally unacceptable by the Federal Environmental Pesticide Control Act. The pesticide industry worked vigorously to have some products retained for major crop use. But financial considerations put a damper on efforts to have clearance extended to some minor crops.

The situation is understandable. Manufacturers who intend to market a pesticide must consider the direct costs of discovering, developing, registering, manufacturing, and marketing their product. Indirect costs also enter into the picture because of possible liability or damage suits. Some suits may run into thousands of dollars per acre for a pesticide costing only a few dollars.

In the past few years, however, some relief has occurred in the registration of pesticides for minor acreage crops. The relaxation came about largely through the efforts of the USDA Interegional Four Committee (IR-4) and the introduction of state and emergency labels for local needs (24c and 18c).

H. J. Hopen and M. C. Carbonneau are professors and D. J. Williams and D. B. Meador are associate professors in the Department of Horticulture. The research reported here was carried out under a grant from the North Central Region, Pesticide Impact Assessment Program, and with the help of J. R. Street, formerly an assistant professor in the Department of Horticulture.

Assessment survey

As an aid to research on minor crops, we recently conducted a survey to find out which horticultural pesticides and practices are being used in Illinois. From a list of growers in each of the 102 counties, we drew a 10-percent random sample representative of six crop categories: 12 floricultural producers, 26 fruit growers, 22 nursery producers, 6 sod producers, 22 lawn care and golf course specialists, and 44 vegetable growers. We then interviewed the 132 selected growers, using a questionnaire designed by the Survey Research Laboratory. Data are from the 1978 growing season.

Decision making and equipment

Producers must make many decisions about pesticides. In 56 percent of the operations surveyed, one person shouldered this responsibility. Two people shared decision making in 25 percent and three people in 11 percent of the operations. Instances of more than three people making decisions were rare.

Respondents indicated that their major sources of information about pesticides were, in order of importance, Extension personnel, dealers, Extension circulars, other growers, and trade journal articles. Less frequently consulted sources were salesmen, books, advertisements in trade journals, friends, relatives, and coworkers. No one relied on radio and television for specific information.

Most respondents (71 percent) applied pesticides themselves or had their own employees do so. Only 6 percent used commercial applicators exclusively. The remaining 23 percent hired a commercial service for some of the work.

Those respondents who did the work themselves used different types of equipment, depending on the crop and target pest: 64 percent used boom applicators; 30 percent, granular applicators; 30 percent, 1- to 5-gallon compressed-air sprayers; and 23 percent, air-blast sprayers. Several minor types of equipment were occasionally used as well. About a fourth of the respondents used aircraft for some applications, most of which were done commercially by fixed-wing planes (16 percent) or helicopters (10 percent).

Safety. Some pesticides are relatively safe and therefore do not require special clothing or equipment. Other chemicals do require extensive safety precautions, which are sometimes ignored by growers. Of the people interviewed, 67 percent wore rubber or neoprene gloves when mixing or applying pesticides, but only 48 percent said they used a washable head covering and 47 percent a respirator or gas mask. The percentages were even smaller for coveralls, boots, and protective aprons.

Storage. Fifty-two percent of the growers stored their pesticides with other material, 45 percent stored them separately, and 3 percent stored them both ways. Most of the growers had some pesticides left at the end of the crop year, but only a few returned them to the dealer. The surplus was generally buried in a noncrop area or stored. A fourth of the respondents applied pesticides for a labeled use other than the original purchase use.

Disposal. The types of pesticide containers and the manner in which they are disposed of are important for health and environmental reasons. In our survey we found that 88 percent of the growers purchased some of their pesticides in plastic or metal containers. Of these respondents, 85 percent used the triple-rinse method of decontamination; 43 percent disposed of the containers in a sanitary landfill and 41 percent

through a commercial waste disposal company. Other methods of disposal were also used occasionally.

Ninety-three percent of the producers used some chemicals packaged in cardboard or paper containers. Two-thirds of these respondents burned the containers on the premises. The remaining third disposed of them in some other way, primarily through a sanitary landfill or a commercial hauling service.

Fruit

Apples. Most of the pesticide treatments in apple orchards were for disease control. The fungicides and bactericides applied in the greatest amounts were metiram, sulfur, and dinocap plus mancozeb. The most frequently used insecticides and miticides were petroleum oil, phosmet, and azinphos methyl. Only a few herbicides and growth regulators were applied.

Peaches. Peaches required more fungicide and less insecticide per acre than did apples. Wettable sulfur accounted for 83 percent of the total fungicide application. The insecticides used in the greatest quantity were parathion, carbaryl, and endosulfan.

Strawberries. Weeds were the main pest in strawberries. Growers used diphenamid and DCPA for their primary source of control.

Turf

Kentucky bluegrass. Twenty-one different pesticides were applied to the acreage surveyed; seven of these were fungicides, ten herbicides, three insecticides, and one growth regulator. The most commonly applied fungicides were tersan LSR, actidione TGF, and daconil. The herbicides used to the greatest extent were 2,4-D, dicamba, and MCPP, all of which were used primarily for control of broadleaf weeds. The most often used insecticides were diazinon, malathion, and chlorpyrifos.

Kentucky bluegrass mixture. Six herbicides and one fungicide were applied to the acreage studied.

Annual bluegrass. Fifteen pesticides were applied to annual bluegrass: nine fungicides, primarily daconil and actidione; and five herbicides, dicamba on 44 percent of the total acreage, and benefin. MCPP, DCPA, or 2,4-D on 29 percent of the acres surveyed. Ethoprop was the only insecticide listed.

Bentgrass. Twenty-seven different pesticides were applied to the bentgrass acreage: fifteen fungicides, six herbicides, and six insecticides.

Floricultural crops

Growers of floricultural crops were surveyed to determine what pesticides and growth regulators they applied in 1978. The crop categories were: bedding plants, chrysanthemums, foliage plants, geraniums, lilies, poinsettias, roses, and other flowering plants. Applications included twelve insecticides and miticides, nine fungicides, five herbicides, and four growth regulators. Multiple applications were common.

Nursery crops

Deciduous shrubs. Benomyl, the most frequently applied fungicide, was used to treat 33 percent of the total acreage of deciduous shrubs. The herbicides simazine, oryzalin, alachlor, and chloropropham were used on a combined 50 percent of the acres surveyed.

Evergreens. Fungicide treatments with benomyl were slight. The most commonly used herbicides were simazine, 53 percent of the acreage treated; oryzalin, 13 percent; and alachlor, 13 percent. The most frequently applied insecticides were malathion, 35 percent; toxaphene, 22 percent; and carbaryl, 21 percent.

Shade trees. Benomyl and zineb, the only fungicides used in any quantity for shade trees, were applied to 7 and 4 percent of the acreage, respectively. The insecticides malathion, diazinon, and carbaryl were applied to a combined 51 percent of the acres planted to evergreens.

Vegetables

We also surveyed commercial growers of twenty-seven different vegetable crops, among them asparagus, beans (green, kidney, lima, snap, wax), peas, popcorn, pumpkins, onions, sweet corn, and tomatoes. Pesticide use for only the last two vegetables is included here.

Sweet corn. The fungicides captan and thiabendozole were used on 48 percent of the acres surveyed. The herbicide atrazine was used on 33 percent and alachlor on 21 percent of the sweet corn acreage. Together, butylate and propachlor were applied to 20 percent, while cyanazine, 2,4-D, and linuron were used on slightly less than 6 percent.

The insecticide carbaryl was applied to 76 percent of the acres planted to sweet corn, with one to six treatments per acre; parathion on 47 percent, with one to fifteen treatments; and methomyl on 11 percent, with one to twelve treatments per acre. Eight other insecticides were also applied. An organic type additive was used on relatively few acres.

Tomatoes. Among the six fungicides used were maneb on 98 percent of the acreage, chlorothalonil on 68 percent, and copper sulphate on 64 percent. Maneb and chlorothalonil were applied two to seven times and copper sulphate four times. The herbicide trifluralin was used on 64 percent of the total acreage in tomatoes, diphenamid on 33 percent, and chloramben on 30 percent.

Of the six insecticides, carbaryl was used on 98 percent, methomyl on 94 percent, malathion on 65 percent, and *Bacillus thurengiensis* on 64 percent of the treated acres. Carbaryl and methomyl were applied one to three times per acre, malathion two to seven times, and *B. thurengiensis* three times per acre. The growth regulator ethephon, used as a ripening aid on 30 percent of the surveyed acres, was applied once per surveyed acre.

The information in this article is a summary of a 103-page report, Horticulture Series No. 22. Readers can obtain one free copy by writing to the Dept. of Horticulture, 124 Mumford Hall, University of Illinois, Urbana, IL 61801.

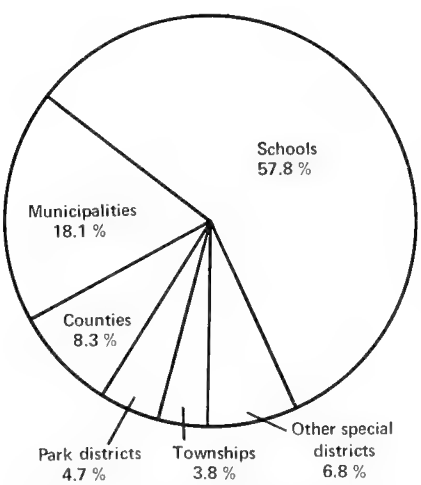
Property Taxes and Public Education

DAVID L. CHICOINE and NORMAN WALZER

PROPERTY TAXES are the principal way that local governments in Illinois finance services. Attention has recently become focused on these taxes because of the increasing size of the public sector and the tax burden on agricultural and residential properties.

Illinois school districts collect the greatest share of the property taxes extended by over 5,200 local governments. In 1977, the most recent year for which complete information is available, schools received 57.8 percent of the more than $4 billion in property tax extensions. This proportion has remained relatively constant during the past decade (Fig. 1).

Education has also become one of state government's heaviest funding responsibilities. Since 1967, state intergovernmental revenues for education have grown from $399 million to more than $2 billion. Today about 45 percent of school revenues comes from state government, compared with only 27 percent in 1967. This shift, along with intergovernmental aid for other local governments, has reduced financial dependence on the property tax. The proportion of all local government revenues coming from property taxes declined from 72 percent in 1967 to 40 percent in 1977.



Percentage of total taxes extended by type of taxing district. (Fig. 1)

Although the relative importance of property taxes in financing local services has declined, recent growth in property values has caused substantial property tax increases in some parts of the state and for certain types of property such as farmland and single-family homes. This increase has created considerable pressure for property tax relief. For example, the 1977 Farmland Assessment Act was enacted to provide relief for land owners, and the homestead exemption for home owners has recently been increased. Historically, substantial property tax relief has been provided through state aid to local schools.

School finance: an overview

Organized by size of enrollment, Table 1 presents a profile of per pupil revenues that school districts obtained in 1977. Although state aid, averaging $782 per pupil, is most important among intergovernmental revenues, a portion of these monies comes from federal sources passed through the state.

The average general revenue collected was $1,769 per pupil, with 49 percent coming from local taxes. A comparison by enrollment reveals little difference among districts because of size. Districts having 10,000 students or more are an exception. In these large districts state aid represents 53 percent of the revenues. Thus, to support the same level of expenditure per pupil, the smaller districts had to raise more revenue from the property tax.

The average expenditure per pupil was $1,704 (Table 1). Labor-intensive educational services require that a high proportion of per pupil expenditures be paid in wages and salaries (62.2 percent, on the average). Substantial variation may of course exist among areas in the state.

Property taxes: unsatisfactory

Growth in state aid to education evolved in an atmosphere of rising expenditures and dissatisfaction with the property tax as a means of raising revenues. Before the inflation-inspired expenditure increases in the late 1970s, schools had to expand to accommodate the children of the post World War II "baby boom."

Property taxation became an unsatisfactory method for financing this expansion. Taxpayers were dissatisfied because of alleged inequities and administrative problems. Furthermore, discontent was aroused because the distribution of the property tax base was generally unrelated to educational needs. Poor communities needed higher tax rates than did the wealthy ones to generate equal amounts of school revenue. In 1977, for example, property wealth among Illinois counties varied from $8,544 to $87,879 when measured on a per pupil basis. Court challenges to traditional systems of educational finance also did much to encourage increased state aid.

State educational aid

The greatest proportion of school aid is allocated to districts by formula. The current method is equalizing: need in relation to fiscal resources is taken into account. This method was not the basis for initial aid programs, however. Adopted in 1927, the first Illinois general aid program guaranteed every school district a minimum amount of revenue.

Because this method, known as the

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Table 1. — 1977 Per Pupil Revenues and Expenditures of Illinois School Districts, by Enrollment Size

Enrollment size	No. of districts (1,059)	Revenues					Expenditures			
		Total	Intergovernmental		Taxes	Other	Total	Salaries and wages	Interest	Other and capital outlay
			Total	State aid						
Average	..	$1,769	$ 782	$771	$ 863	$123	$1,704	$1,099	$52	$553
10,000 or more	31	1,900	1,011	999	784	105	1,830	1,189	63	578
6,500 to 9,999	30	1,748	612	603	981	155	1,632	1,099	42	490
3,000 to 6,499	93	1,720	606	587	957	157	1,678	1,067	48	563
1,000 to 2,999	324	1,625	644	636	855	126	1,580	999	46	534
600 to 999	190	1,624	645	641	874	105	1,541	983	40	519
300 to 599	197	1,735	591	589	1,038	106	1,671	1,070	35	566
Less than 300	194	1,662	637	632	923	103	1,601	1,008	28	565

Source: U.S. Bureau of the Census, "Finances of School Districts, Governments," 1977, Vol. 4, no. 1, Table 9.

Strayer-Haig formula, ignored local disparities in district property wealth, it failed to provide equal protection to pupils in property-poor districts. In 1973, the Resource Equalizer formula was added as an option to overcome these weaknesses. However, since the old formula favored wealthy districts, it was not abandoned until 1980, and districts chose the more favorable formula.

The Resource Equalizer approaches aid through guarantees of per pupil assessed valuation and provides funds in an inverse relationship to district assessed valuation per pupil. State aid thus increases with a decrease in local district property wealth.

The basics of the Resource Equalizer are:

$$SA = (GV - DV) \times R$$

Where:

SA = state aid per pupil
GV = guaranteed assessed valuation per pupil
DV = district's actual per pupil assessment
R = district's operating tax rate

Actual calculations include weighting for high school, kindergarten, and low income students. Through this formula the state assures each district per pupil revenues equal to the local tax rate applied to the guaranteed assessment. In 1980, the guarantee was raised to $51,696, which provides $1,463 per pupil in local and state revenues. The actual amount received by districts, though, depends on whether sufficient Common School Fund appropriations are made.

As an example of how a district's aid is calculated with the Resource Equalizer, imagine a hypothetical unit district with a total assessed valuation of $300 million, an operating tax rate of 2.83 percent (the maximum allowed for aid calculation), and a weighted enrollment of 15,000 students. Assessed valuation per pupil is thus $20,000. SA = ($51,696 − $20,000) × 0.0283, or $897. SA added to local property tax revenues of $566 ($20,000 × 0.0283) yields the statutory revenue maximum of $1,463. In similar fashion, close to $2 billion in state tax dollars is allocated annually to more than 1,000 Illinois school districts.

The equalizing force inherent in the formula can be seen in the amount of state aid allocated to counties in 1978. The ten wealthiest counties averaged $258 in aid per pupil, while the ten poorest counties averaged $1,093. Cook County received $803 per pupil.

Scale effect

The levels of state aid reported in Table 1 suggested the possibility of an implicit scale effect in the distribution of aid among Illinois school systems, with larger districts receiving more per pupil than smaller districts. We investigated this possibility statistically, using Illinois counties as observations.

The results of the regression analysis suggested that the number of school-age children in a county does influence per pupil aid levels, other things being equal. The sign, size, and statistical significance of the analytical results indicate that for every 1-percent deviation from the average school enrollment, aid per pupil deviates by 0.07 percent. According to these results, pupil aid increases at a decreasing rate with county pupil population.

The exact reasons for this relationship are unclear. Important factors may have been excluded from the analysis, or those included may not have been accurately measured. Given these potential shortcomings, the analysis suggests an implicit bias in the distribution of state aid towards more dense, urban counties and away from rural, sparsely populated counties.

When considering state aid to education as a means of property tax relief or in general, policy makers may need to look at the consequences of alternatives in light of this possible scale effect. On the basis of demographics, it is difficult to argue that pupils in densely populated counties are more deserving of state aid than pupils in rural areas. This issue warrants further investigation.

State intergovernmental aid for education is under continuing review, and alterations are frequent. This allows for flexibility, but concomitantly creates opportunities for political maneuvering. Changes should be adequately evaluated to minimize undesirable, unexpected consequences while progress continues toward an adequate, equitable method of financing the demands for local government services.

Homemakers Questioned About Food Satisfaction

SHARON P. LITHERLAND and JEANNE L. HAFSTROM

WHY ARE SOME PEOPLE more satisfied than others with their food consumption? What characteristics explain why one person prefers to eat at home, while the next person is more satisfied eating away from home? Does a wife's employment status influence her satisfaction with food eaten at home or elsewhere?

These and related questions have received little attention despite a wide and ever expanding body of research on food consumption patterns. Knowing the answers should enhance our understanding of the economic behavior of individuals and families with respect to food. We therefore developed a study to identify those factors that affect homemakers' satisfaction with food consumption at home and away from home.

Data used in the study were collected by personal interviews with Champaign-Urbana homemakers who participated in the 1976-77 Quality of Life Survey conducted by Family and Consumption Economists at the University of Illinois. This study, which involved a reinterview of participants in a 1970-71 survey, assessed homemakers' satisfaction in many areas of life.

We included 231 women from husband-present families in an analysis of satisfaction with food eaten at home, and 217 of the same women in a separate analysis for food eaten at restaurants, drive-ins, and the like. The reason for the reduced sample is that 14 of the homemakers rarely, if ever, ate out.

Sample characteristics

Mean size of the respondents' families was 4.1, with a range of 2 to 9 members. The wives' average age was 44, and the husbands', 47 years.

Three-fifths of the wives were working outside the home at the time of the interview. Of these women, 18 percent were in blue-collar and 82 percent in white-collar occupations. Among the husbands, white-collar jobs also predominated (71 percent). The median family income before taxes was $25,000.

Expenditures and satisfaction

One of the sample families spent as much as $250 a week for food eaten at home, but the mean expenditure was considerably less. For the entire sample it was $55.96 and for the reduced sample $55.18. Keep in mind that these figures are for 1976-77. At today's prices, the grocery bill would probably be significantly larger.

Away from home the sample families spent up to $50 a week for food. For the total sample the mean expenditure was $11.88, compared with $12.65 for the reduced sample. The number of times the family ate out per month ranged up to 50, with a mean of 4.4 for the total and 4.7 for the reduced sample.

A large majority of homemakers preferred the food they had at home to that eaten elsewhere. This finding was based on the responses to two questions: In general, how satisfied are you with the food you eat at home? In general, how satisfied are you with the food you eat away from home at restaurants, drive-ins, and so forth?

Nearly four-fifths (78 percent) of the respondents said they were satisfied or very satisfied with the food when eating at home, compared with just under a half (49 percent) when eating away from home. At the other end of the scale, very few homemakers were completely dissatisfied with the food at home:

At home	
Dissatisfied	7%
Somewhat satisfied	16%
Away from home	
Dissatisfied	13%
Somewhat satisfied	38%

Differences in satisfaction with food eaten at home can be explained by some of the variables in the analysis:

- Socioeconomic: stage in the family life cycle, race, age and employment status of the homemaker
- Social-psychological: satisfaction with how often the family eats out each month, the wife's role in making decisions, her perception of how well the husband's income is keeping up with prices
- Food consumption: weekly expenditure for food at home and for food away from home

The variables related to eating away from home were: stage in the family life cycle, age of the homemaker, occupational status of both husband and wife, and satisfaction with the type of eating establishment. To find the relative importance of these variables, we used a multiple regression analysis.

Food at home

A homemaker's satisfaction with the food eaten at home was significantly affected (0.05 or better) by the amount of money spent each week

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for food away from home, the woman's employment status, and her satisfaction with how often the family ate out per month. The last of these variables was the most important: the more satisfied the woman was with how often the family went out to eat, the more likely she was to be satisfied with food eaten at home.

Negatively related was the family's weekly expenditure for food when eating out: the less money spent, the greater the homemaker's satisfaction with eating at home. Also negatively related was her employment status. Employed wives were less likely to be satisfied with eating at home than were full-time homemakers.

Only about 10 percent of the variance in homemaker's satisfaction with food at home was explained (significant at the 0.01 level). This means that we need to find additional factors to improve our understanding of why some women are more satisfied than others when eating at home.

Food away from home

Age was significant in explaining a homemaker's satisfaction with food eaten away from home. Older women were apt to prefer the food eaten out to home cooking. But the more important variable by far was where the family went to eat. The more satisfied the wife was with these places, the more likely she was to be satisfied with the food eaten away from home.

To gather information about where the respondents ate, we asked them to list the names of eating places frequented by their families. The places named were then divided into fast food, moderately priced, higher priced, and country club or private eating establishments. Depending on the type of restaurant frequented, the respondents were put into one of four groups:

- Group I — fast food or moderately priced restaurants, or a combination of both
- Group II — a combination of fast food or moderately priced and higher priced restaurants
- Group III — higher priced restaurants only

Table 1. — Homemakers' Satisfaction With Food Away From Home by Type of Restaurant Frequented[a]

	Group I[b]	Group II[b]	Group III[b]	Group IV[b]
	Percent			
Dissatisfied	2	3	6	0
Somewhat dissatisfied	5	4	6	0
Neither satisfied nor dissatisfied	7	5	17	0
Somewhat satisfied	35	41	39	42
Satisfied	47	45	33	47
Very satisfied	3	3	0	11

[a] Homemakers responded to an open-ended questionnaire by listing where they usually go when eating out. The responses were grouped into four categories: Group I = fast food or moderately priced restaurants, or a combination of both; Group II = a combination of fast food or moderately priced and higher priced restaurants; Group III = higher priced restaurants only; Group IV = country club or other private restaurant or club, or a combination of both.
[b] Group I, n = 99; Group II, n = 81; Group III, n = 18; Group IV, n = 19.

- Group IV — country club or other private restaurant or club, or a combination of both

Group IV (9 percent of sample), consisting of homemakers whose families ate at country clubs or other private clubs, appeared to be the most satisfied with their food away from home. No one in this group said she was dissatisfied with the food. All were somewhat satisfied, satisfied, or very satisfied (Table 1).

The second most satisfied homemakers were in group II (37 percent of sample), those whose families ate at a combination of fast food or moderately priced and higher priced restaurants. Eighty-nine percent were at least somewhat satisfied with their food away from home. Group I homemakers (46 percent of sample) were next, with 85 percent responding that they were at least somewhat satisfied with fast food or moderately priced restaurants.

Group III homemakers (8 percent of sample), those whose families ate only at higher priced restaurants, were the least satisfied with their food away from home. Only 72 percent indicated that they were somewhat satisfied or satisfied; no one in the group was very satisfied.

Since nearly half of the variance in homemaker's satisfaction with food eaten away from home was explained by the respondent's age and where the family went, these two variables were quite helpful in adding to our understanding of food consumption behavior.

Improved management

These findings provide valuable insight for those of us concerned with helping Illinois families improve the management of their resources. By knowing the factors that contribute to homemakers' satisfaction with food consumption, advisers are in a better position to help families make decisions that will improve their allocation of resources for food at home and away from home to obtain maximum satisfaction.

Yet these findings raise some relevant questions as we attempt to deal with problems experienced by families. For instance, we found that gainfully employed homemakers are less likely to be satisfied with their home food consumption than are homemakers not employed outside the home. Does this relationship hold true for women in all types of occupations? Does full-time or part-time work influence the relationships?

Also, the survey results indicate that the less money the family spends for food away from home, the more satisfied the homemaker is with the food at home. And the more satisfied she is with how often the family goes out to eat, the more satisfied she is with food prepared at home. These findings suggest that the relationship between food consumption at home and away from home should be explored further.

This study analyzed food satisfaction of only the wives. In future research, husbands might be interviewed as well to find out if there are differences in what determines their food satisfaction. A more comprehensive analysis, including a wider range of socioeconomic, social-psychological, and food-consumption-related variables, would be helpful in identifying other key factors.

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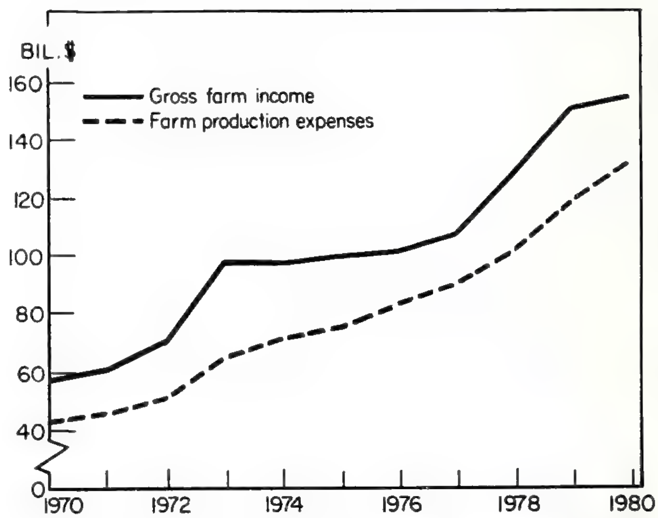
FARM BUSINESS TRENDS

NET FARM INCOME in the United States for 1980 declined substantially from the previous year. Indications are that income will make a sizable gain in 1981, perhaps recovering most of the 1980 losses. Higher prices for most farm commodities will boost incomes. Although rising prices will again lift the level of farm costs, the increase will probably not be as great as that in receipts.

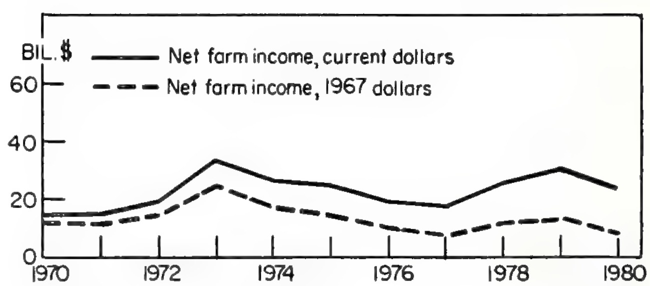
Each year during the 1970s gross farm income climbed steadily upward (Fig. 1). The increase in farm production expenses also followed the same trend. On the other hand, net farm income in current dollars has varied little during the past decade (Fig. 2). When constant 1967 dollars are used to remove the impact of inflation, incomes in recent years tend to be slightly lower than in the early 1970s.

The international market for agricultural products is again expected to be a major force favoring a rise in agricultural income. Volume of agricultural exports for the year ending September 30, 1980, was estimated at 162 million metric tons, with a value of $40 billion. U.S. exports of feed grains increased from about 20 million metric tons in 1970 to 71 million tons in the year ending September 30, 1980. Corn exports went from about 517 million bushels to 2,500 million. As incomes increase in the rest of the world, there is a growing demand for more meat and dairy products and thus a need for more grains to feed livestock. Indications are that we can expect an additional increase in both volume and value of agricultural exports. Because of adverse weather in 1980, U.S. crop production was down substantially last year, thereby causing total grain stocks to decline and prices to rise.

Illinois farm incomes should be in an especially favorable position. As major suppliers of corn and soybeans, grain farmers in particular should see an improvement in their income. — *M. B. Kirtley, Extension economist in livestock marketing*



Gross U.S. farm income and production expenses, 1970-80. (Fig. 1)



Net U.S. farm income, 1970-80. (Fig. 2)

Spring, 1981

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

IN THIS ISSUE

With care, corn damage from conventional and rotary combines can be kept below one percent (page 10).

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN COLLEGE OF AGRICULTURE Volume 23, Number 2

ILLINOIS RESEARCH

Illinois Agricultural Experiment Station

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(Cover picture by Paul Hixson)

Spring, 1981 Volume 23, Number 2

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R. G. Cragle . . . . Director

Sheila A. Ryan . . . . Editor

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THE *ILLINOIS RESEARCH* STORY — A NEW CHAPTER

ILLINOIS RESEARCH is in transition. The next issue, scheduled to appear in the fall, will mark the change between old and new. In a double issue we will present a panoramic view of the Agricultural Experiment Station, its activities, concerns, and the personnel who are at the heart of many new and exciting developments. Whether our readers live on farms, in small towns, or in cities, we want them to know about the work the Station is doing for them.

Now, far more than ever before, many nations around the globe benefit from the improvements in U.S. agriculture. With the expanding markets, Illinois has assumed a major international role, exporting more agricultural products than any other state.

Food is everyone's concern. But the advances in agriculture do not end there. The United States is undergoing a major transition in the way it supplies and uses its resources. The development of renewable sources of energy has become imperative, and agriculture is fast becoming the industry that can most readily respond to this task.

Our nation still has a long way to go if it is to meet its future agricultural needs. Energy in particular is running short. The drain is felt everywhere by everyone, and the problem will undoubtedly get worse before it gets better. Awesome to say the least, the staggering demand for food and renewable energy supplies raises the specter of irreparable soil and groundwater losses from the use of intensive cultural practices. Intertwined with the well-being of society, these practices are one of our most immediate research concerns.

The new *Illinois Research* will be an integral part of the Station's efforts to pose difficult problems and offer bright new opportunities. The publication will weave together governmental policy, consumer interests, the economics of situations, and the scientific possibilities that are common to any agricultural enterprise.

As we close a chapter, we wish to express our gratitude to Margery Suhre, who brought *Illinois Research* into existence in 1959. The publication has flourished for more than twenty years, thanks to her outstanding editorial abilities. Her important service to the Station through those years is deeply appreciated. — *R. G. Cragle*

Farmers' Views on Agricultural Issues

HAROLD D. GUITHER

THE FOOD and Agricultural Act of 1977 set the basic course for the nation's agricultural and food policy from 1978 through 1981. This year, Congress will have to decide whether the 1977 Act will be extended, revised, or repealed.

To gain some insight into how Illinois farmers view current agricultural and food issues, we surveyed 1,500 farmers in November and December, 1980; 411 usable responses were received. Drawn by the Illinois Cooperative Crop Reporting Service, the sample is representative of all Illinois farm operators. Characteristics of the respondents are shown in Table 1.

Role of government

Farmers were asked, "What do you think Congress should do about future farm legislation in 1981?" Responses were divided: 37 percent want the present law kept but with minor changes in loan rates, target prices, and reserves; 31 percent want all government price and income support programs eliminated, including the reserve program. Another 14 percent would like totally new farm legislation developed, and 18 percent had no opinion or did not answer.

The farmers most in favor of keeping the present law are between 30 and 39 years of age and 60 or older. They farm 1,200 acres or more, are high school graduates or have attended some college, or receive the major part of their farm income from grain or from half grain and half livestock.

Those most in agreement with eliminating all support programs are dairy farmers, are 50 or older, operate 1,200 acres or more, or have not graduated from high school. The feeling that Congress should develop completely new legislation was strongest among grain farmers who are between 40 and 49 years of age, farm 650 to 1,199 acres, or have graduated from high school.

Harold D. Guither is Extension economist and professor of agricultural policy.

Target prices and loan rates

Illinois farmers would like to see higher target prices and loan rates. Responses were probably influenced by inflation and rising production costs. The average recommendations for 1981 are presented below, along with the actual 1980 rates:

	Recommended for 1981	*Actual for 1980*
Target prices		
Corn	$3.06	$2.35
Wheat	4.32	3.63
Loan rates		
Corn	2.85	2.25 (2.40 in reserve)
Wheat	3.84	3.00 (3.30 in reserve)
Soybeans	6.40	5.02

One proposed change in the support program entails discontinuing the target-price program and emphasizing the reserve program to support farm prices. Thirty percent agreed with this proposal, 35 percent disagreed, and 35 percent had no opinion or did not answer the question. When farmers were asked their views of two loan rates — one for crops not in the reserve and the other for those placed in the reserve — 27 percent agreed with the idea, 31 percent disagreed, and 42 percent had no opinion or did not answer.

Farmer-held grain reserve

Farmers have mixed views about the merits of the farmer-held grain reserve, which was begun in 1978. Although 35 percent agreed that it has been a good program for farmers, 41 percent disagreed, and 24 percent had no opinion or did not answer. On the other hand, 62 percent agreed that consumers benefit from the program; only 11 percent disagreed, and 27 percent had no opinion or did not answer.

Farmers also tend to favor higher release prices from the reserve. For feed grains, 45 percent agreed that release prices should be raised above the present 125 percent of loan rate, 17 percent disagreed, and 38 percent had no opinion or did not answer.

Table 1. — Characteristics of 411 Illinois Farmers in Survey of Farm Policy Issues

	Percent of total
Respondent's age	
Under 30	6
30–39	12
40–49	24
50–59	30
60 and older	25
No answer	2
Acres farmed in 1980	
Under 339	53
340–649	31
650–1,199	12
1,200 and over	4
Major source of farm income	
Grain	66
Hogs, beef	11
Dairy	5
Half grain, half livestock	16
Other	2
Family earnings from nonfarm sources, pct.	
Less than 25	35
25–49	9
50–74	9
75 and over	12
No answer	35
Last year of school completed	
Grade school	11
Some high school	11
High school graduate	48
Some college	14
College graduate	13
No answer	3
Major organization membership	
Farm Bureau	75
Farmers Union	4
Grange	1
National Farmers Organization	1
American Agr. Movement	1
Pork Producers	13
Cattlemen's Association	7
Corn Growers	9
Soybean Association	17
Milk Producers	4
Labor Union	8

For wheat, 32 percent favored higher release prices, 14 percent disagreed, and 54 percent had no opinion or did not answer.

According to 31 percent of the respondents, the call prices of 45 percent above the loan for feed grains and 75 percent above the loan for wheat are about right, considering the interests of both producers and consumers; 25 percent disagreed, and 44 percent either had no opinion or did not answer. Farmers also favor a single release and call price for all producers, no matter when their grain is placed in the reserve: 39 percent agreed, 20 percent disagreed, and 41 percent had no opinion or did not answer.

The fact that many farmers have no opinion about the grain reserve suggests either that they have not participated in the set-aside program or that they were not eligible or have not used the reserve since it began in 1978.

Limitation on exports

Suspension of agricultural exports to Russia in 1980 became a major policy issue among farmers and their organizations. Respondents in the survey had very strong feelings about the issues.

Farmers were divided on whether the President was right in declaring the embargo: 36 percent agreed with him, 52 percent disagreed, and 12 percent had no opinion or did not answer. On the basis of what happened during 1980, 63 percent believe that the United States should not limit farm exports for political or foreign policy reasons; 24 percent disagreed, and 13 percent had no opinion or did not answer.

Looking ahead to the 1981 farm bill, 77 percent believe that the bill should provide price protection for producers if exports are limited for any reason; 10 percent disagreed, and 13 percent had no opinion or did not answer. The five-year export agreement with Russia, specifying minimum and maximum quantities, expires on September 30, 1981. A significant 59 percent favored renewal; 23 percent disagreed, and 18 percent had no opinion or did not answer.

Control of exports

Farmers generally do not approve of government efforts to control prices or exports. One survey question asked if government should seek agreements with other exporting countries to hold reserves, control production, and raise prices. In response, 38 percent indicated approval, 41 percent did not approve, and 21 percent had no opinion or did not answer. When asked if they favor a national board to control the marketing of U.S. grain exports, 30 percent agreed, 52 percent disagreed, and 18 percent had no opinion or did not answer.

Other policy issues

Help for small farms. A majority of those responding go along with the idea of increasing price and income supports for farms with annual sales under $40,000: 54 percent agreed, 31 percent disagreed, and 15 percent had no opinion or did not answer.

Disaster payments and crop insurance. The 1980 Crop Insurance Act was designed to replace the disaster provision of the Food and Agriculture Act of 1977. The proposal calls for a more comprehensive crop insurance plan that will be paid for jointly by the producer and the government. Among the respondents, 43 percent seemed willing to shift to the new insurance plan, 36 percent disagreed with the change, and 21 percent had no opinion or did not answer. Many respondents were probably not acquainted with the new program.

Soil conservation. Recognizing the losses caused by soil erosion, a majority of farmers would be willing to follow a recommended conservation plan to qualify for price and income support benefits. While 52 percent agreed with the idea of cross-compliance, 35 percent disagreed, and 13 percent had no opinion or did not answer.

Land ownership. Respondents favor restrictions on the purchase of U.S. farmland by foreigners: 69 percent agreed with imposing restrictions, 18 percent disagreed, and 13 percent had no opinion or did not answer. But farmers do not want restrictions on the purchase of farmland by U.S. nonfarmers: only 29 percent were for restrictions, compared with 53 percent against; 18 percent had no opinion or did not answer.

Food stamps. The food stamp program has lost favor with farmers. While 29 percent agreed that tax funds should be used to buy food stamps for low income people, 51 percent disagreed; 20 percent had no opinion or did not answer. Also, 54 percent would like to see food assistance programs transferred to the Department of Health and Human Services (formerly Health, Education and Welfare); 22 percent disagreed, and 24 percent had no opinion or did not answer.

Research and extension activities. A majority of those responding to the survey favored an increase in funds for agricultural research and extension: 66 percent agreed, 18 percent disagreed, and 16 percent had no opinion or did not answer.

Application of survey findings

This survey of Illinois farmers' views on current policy issues is useful in several ways. First, when taking policy positions, farm organizations have some idea of the way farmers feel about the issues. The findings can be used to show where the major organizations may differ from a representative sample of all farmers.

Second, the members of the House and Senate agriculture committees will be making decisions about the Agriculture Act of 1981. Committee members have already shown interest in the views expressed in the Illinois survey, along with surveys taken in other states.

Finally, results of the survey help farmers find out if their views are in the majority or minority on specific issues.

Jawbone Feed Bowl And Ingestion Rate

H. B. PUCKETT, E. F. OLVER, K. E. HARSHBARGER, and S. L. SPAHR

WITH THE AID of an electronic system, feed concentrate can be automatically dispensed to cows according to their milk production. The system makes it possible to conserve labor and feed, but dairymen have run into an unexpected snag. Cows tend to dawdle in the feed stalls. Because the stalls are an expensive part of the system, the traffic through them should be kept moving for maximum efficiency.

The hemispherical shape of the feed bowl seemed to be a problem in the early models, because a cow spent considerable time licking the bowl to obtain her ration. We theorized that if the bowl were shaped much like the cow's lower jawbone, with the feed directly in front of the muzzle, the ingestion rate might increase and more cows could be fed per stall.

To test this theory, we set up two experimental stalls equipped with instruments and the jawbone feed bowl. Forty high producing cows were placed in the lot and received their grain from either stall. The stalls had movable sides that could be extended to 7 feet or shortened to 5.3 feet. During the first four weeks of the experiment the cows were programmed to receive an average of 500 pounds of feed through each stall per day, 400 pounds the second four weeks, and 300 pounds the last four weeks.

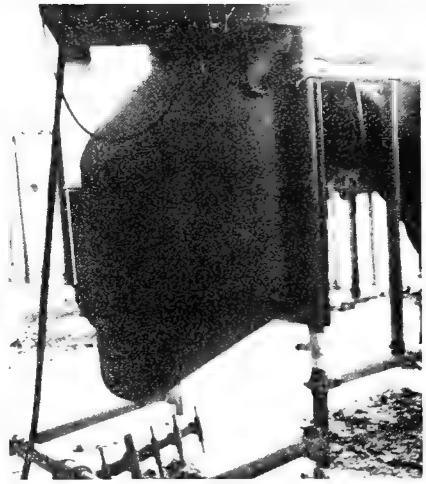
Day and night occupancy time, feed-dispensing time, and use of the stalls were recorded twice daily at milking time. The dispenser timer operated whenever the motor for the feed dispenser was turned on. The use counter registered when the stall became occupied and when the feed dispenser was activated. If a cow entered the stall but did not activate the dispenser, use was not registered. Data from these tests were compared with previous tests using a hemispherical feed bowl.

With the jawbone bowl the average ingestion rate increased 34 percent, from 0.37 pound per minute for the hemispherical bowl to 0.50 pound for the jawbone bowl. The amount of concentrate consumed per entry also increased, from 0.31 pound to 0.41 pound.

But other conditions affected the use pattern as well. For example, turnover was increased by using a short-sided stall. Because the feeding cows were more open to butting from waiting cows, use of this stall resulted in reduced occupancy time per entry. Overall, however, nothing was gained: the average ingestion rate did not improve significantly and the amount of feed received per entry was actually lower.

Location of the stall did make some difference, however. One of the two test stalls was next to a wall, which limited the visibility of approaching cows and of the feeding cow. With less interference from the barn lot "pecking order," cows in the protected stall ingested feed at the rate of 0.46 pound per minute, compared with 0.42 pound in the unprotected stall.

The higher the demand for feed from the stall, the greater the stall use. At all three dispensing rates, the cows used the stalls about the same percentage of the available time, and also stayed in the stalls about the same length of time after the dispenser had stopped. The feed received per entry decreased as the amount of feed programmed was reduced from 500 to 400 to 300 pounds per stall. This finding indicates that the number of cows per feeder, or pounds of grain programmed per feeder, could be even higher than our highest rate of 20 cows and 500 pounds of feed per stall without overloading the system.



This feed bowl, shaped like the lower jawbone of a cow, may help to increase the feed ingestion rate.

The cows occupied the stalls at night a greater percentage of the time than during daylight hours. However, the feed dispensers were operated with about the same frequency during the two periods. The amount of feed received per entry was also about the same for both periods.

The day of the week made a slight difference in the amount of feed dispensed per entry. The most obvious reason for the variation is that the settings on the transponders, the devices controlling the amount of feed per cow, were changed on the third day of every fourth week. The change resulted in a significant reduction in the feed dispensed through each feeder.

The jawbone feed bowl is one of many factors we are investigating to help improve the use pattern of electronically controlled feed dispensers. Integrating the behavior of cattle with equipment design is a constant challenge in our development of management systems for livestock.

H. B. Puckett is research leader with USDA-SEA Agricultural Research; E. F. Olver is professor of agricultural engineering; K. E. Harshbarger is professor emeritus, and S. L. Spahr is associate professor of dairy science.

Double Cropping and Intercropping

An economic evaluation of planting soybeans after small grains in Illinois

R. L. McBROOM, C. M. BROWN, and H. H. HADLEY

Double cropping and relay intercropping are methods for producing two crops in one year on the same land. When the advantages and limitations are properly understood, the two systems may help to increase productivity in Illinois.

In double cropping, a second crop is planted after the first is harvested. The method has been used extensively in the southeastern United States, where the growing season is longer than in the Midwest. Now, with improved techniques for timely planting of the second crop, farmers farther north have been able to take advantage of this cultural practice. Several crop combinations are possible, but generally the most widely used system is to plant soybeans after harvesting winter wheat.

In relay intercropping, soybeans are planted in the small grain before harvest. Compared with soybeans grown in the conventional double-cropping system, intercropped beans have about a month's head start and thus a longer growing season. Interest in relay intercropping is on the upswing because the practice can be adopted even farther north than double cropping. Sometimes called interseeding, interplanting, or simply intercropping, this method has recently been tried in the Midwest, using soybeans with winter wheat or spring oats.

Both double cropping and relay intercropping have some distinct advantages over planting a single crop. For one thing, under the right conditions these methods can increase productivity. Another advantage is that the cover from two crops provides just that much more control of soil erosion than the cover from a single crop.

Field trials

To get a better idea of yield levels and economic returns that might be realized from the two practices, we conducted experiments at Urbana and 150 miles farther north near DeKalb during 1979. The cropping systems studied were:

- monoculture of winter wheat
- monoculture of soybeans
- intercropping of soybeans with winter wheat
- intercropping of soybeans with spring oats
- double cropping of soybeans after winter wheat (at Urbana only)

The same soybean cultivars were used in each system; yields reported here are means for all cultivars in each system. At Urbana, monoculture soybean plots were planted May 29, 1979, at row spacings of 16 inches. Double-cropped beans were planted without tillage on July 7 after the wheat harvest.

The cultivar Hart was used in all systems that included wheat, while Lang was used in all systems with spring oats. The wheat was planted in early fall, 1978, and the oats in early spring, 1979. Monoculture wheat and oats were planted in rows 8 inches apart.

In the intercropping experiments, the rows of small grains were 16 inches apart. To prevent damage to these crops, the soybeans were interplanted between the rows with a cone-type hand planter. At Urbana the beans were planted in the wheat on May 29 and in the oats on June 15.

Because June was extremely dry at Urbana that year, the intercropped wheat plots were irrigated with an inch of water on June 5 and another inch on June 22. The intercropped oat plots were irrigated with 1½ inches of water on June 22 only. We felt that this much additional water was needed to compensate for the below average rainfall at Urbana. Satisfactory weed control was obtained with an experimental combination of herbicides.

At DeKalb, monoculture soybeans were planted at 30-inch row widths on May 18. Soybeans were interplanted in the wheat on June 12 and in the oats on June 25. The planting method was the same as at Urbana. Double cropping was not attempted at DeKalb, nor were the plots irrigated.

Expenses

Expenses for the various cropping systems were based on custom rates charged in 1979 (Table 1). Cost of soybean seed was calculated for planting rates of 1 bushel per acre for monoculture, 1¼ bushels for intercropping, and 1½ bushels for

R. L. McBroom is a former graduate assistant in the Department of Agronomy. C. M. Brown and H. H. Hadley are professors in the department.

double cropping. The expenses are only for variable costs; fixed costs were the same for all systems. The income for each cropping system was computed on the basis of $2.81 per bushel for wheat, $1.32 for oats, and $6.21 for soybeans, the average prices received by farmers between 1975 and 1978.

Table 1. — Estimated Expenses for Five Cropping Systems, 1979

Seed and operation	Monoculture wheat	Monoculture soybeans	Intercropped soybeans and oats	Intercropped soybeans and wheat	Double-cropped soybeans and wheat
	cost per acre				
Primary tillage	$ 4.48	$ 4.48	$ 4.48	$ 4.48	$ 4.48
Planting small grain	3.40	...	3.40	3.40	3.40
Small grain seed	12.50	...	6.00	12.50	12.50
Fertilizer	48.00	34.00	48.00	48.00	48.00
Harvesting small grain	11.35	...	11.35	11.35	11.35
Harvesting straw	25.00	...	...	...	25.00
Planting soybeans	...	9.62	5.25	5.25	5.25
Soybean seed	...	10.80	13.50	13.50	16.20
Herbicide	...	12 50	12.50	12.50	15.00
Cultivation (2)	...	8.00	...	...	...
Harvesting soybeans	...	13.61	13.61	13.61	13.61
Total variable costs	$104.73	$93.01	$118.09	$124.59	$154.79

Returns

Average crop yields and gross and net income per acre for the three cropping systems are shown in Table 2. At Urbana, the wheat-soybean double crop returned a net income of $327 per acre, and the wheat-soybean intercrop, $344. The return for monoculture soybeans was $286 per acre and for monoculture wheat, $209. However, the cost of irrigating the intercropping plots was not included.

If the yields of only the best soybean cultivar in each experiment are considered while keeping wheat yields constant, the return for monoculture soybeans was $329 per acre; for double-cropped wheat and soybeans, $339; and for intercropped wheat and soybeans, $410. The difference of $81 per acre between monoculture soybeans and intercropped wheat and soybeans may not be enough to pay for irrigation. But if soybean yields are lower than those in this study and are limited by water, relay intercropping of soybeans and wheat would probably come closer to paying for irrigation than would monoculture soybeans.

At DeKalb the results were reversed: returns for monoculture soybeans were greater than for the wheat-soybean intercrops, perhaps because the growing season is shorter at DeKalb than at Urbana. However, net returns for both monoculture soybeans and for the wheat-soybean intercrop were greater than for monoculture wheat (Table 2).

At both locations, net income from the oat-soybean intercropping experiments was much lower than from any other cultural system except monoculture wheat (Table 2). In the intercropped oats and soybeans, average soybean yields were only 2 to 3 bushels per acre less than in the intercropped wheat and soybeans. But oat yields and their market value were so low that overall economic returns for the oat-soybean system were poor.

Table 2. — Yield and Income for Five Cropping Systems, 1979

Location and system	Yield	Grain receipts	Straw receipts	Gross income	Net income[a]
	bushels per acre	*income per acre*			
Urbana					
Monoculture wheat	94	$264	$50	$314	$209
Monoculture soybeans	61	379	..	379	286
Intercrop					
Oats	60	79	..	328	210
Soybeans	40	248	..		
Intercrop					
Wheat	74	208	..	469	344
Soybeans	42	261	..		
Double crop					
Wheat	94	264	50	482	327
Soybeans	27	168	..		
DeKalb					
Monoculture wheat	71	200	50	250	145
Monoculture soybeans	56	348	..	348	255
Intercrop					
Oats	38	50	..	199	81
Soybeans	24	149	..		
Intercrop					
Wheat	55	155	..	322	198
Soybeans	27	168	..		

[a] Net income was calculated as gross income minus variable costs.

Keep in mind that these findings are for only one year. Also, a greater weather-related risk is associated with relay intercropping than with monoculture. At some locations where supplemental irrigation is unavailable, lack of rainfall in June could cause the second crop (soybeans) to fail.

Even with these risks, though, relay intercropping of soybeans and wheat may have the potential for increasing economic returns per unit area of land. Experiments are being continued to determine the yield levels and economic returns that might be expected over different years and at a wider range of locations.

A Young Child's Memory For Location of Objects

JUDY S. DELOACHE

SUPPOSE YOU REACH for your car keys in the place where you remember putting them last night — on the table beside the couch. Much to your surprise, the keys are not there. What do you do next?

You might first accuse your spouse of moving them, but after he or she denies the accusation, you are likely to search for the missing keys. In all probability you would look in places related in some way to the original place. For example, you might look under the table or among the pillows and cushions on the couch.

This kind of searching can be characterized as *intelligent* because you reason that the keys might have been brushed off the table onto the floor or couch. The search is also *organized* because you carry out a series of related actions to achieve a specific goal.

Although not particularly sophisticated, the example does make clear that an effective search requires (1) the ability to draw plausible inferences about previous events, and (2) the ability to organize one's activities in the pursuit of a goal. Research I am conducting with very young children suggests that even two-year-olds are quite competent at remembering the locations of things and are capable of simple forms of reasoning and organization similar to those used by adults.

Searching for hidden objects

The main focus of this research is on toddlers' memory for the location of objects hidden in the environment. The memory task takes the form of a hide-and-seek game played with a small stuffed animal such as Big Bird. The children are told that Big Bird is going to hide and that they have to remember where he's hiding to be able to find him later.

The child watches while the toy is hidden somewhere in the child's own home. The toy might be hidden under a pillow on a chair, under couch cushions, or behind a bookshelf. A timer is then set for a specified interval, usually 3 to 5 minutes, and the child is taught to wait for the bell to ring. When it does, he or she is allowed to retrieve the "hiding" toy. The children very readily learn the rules, because this form of hide-and-seek has the appeal and excitement of a real game.

Several studies have now been carried out using the basic hide-and-seek format. The general level of performance of young participants 18 to 30 months old has been excellent. In 75 to 85 percent of the trials, the children go directly to the correct location without making any kind of error, thus showing that they are quite competent at remembering the location of objects in the natural environment.

The children's memory for location is relatively unaffected by how long they have to remember. In one experiment the intervals between hiding the toy and retrieving it were extended to 30 and 60 minutes and overnight. Even these lengthy delay intervals did not disrupt the performance of the children. They were as likely to find the toy after an hour or overnight as after 5 minutes.

But what do these studies of toddlers looking for Big Bird have to do with searching for lost car keys? One of our hide-and-seek studies provides data suggesting that the ability to conduct an organized and intelligent search may emerge at around two years of age. In this particular study, we were interested in discovering how sure the children were that they correctly remembered the location of their toy. To assess their certainty, we surreptitiously moved the toy while the child was out of the room. In these two surprise trials, the toy was hidden as usual, but was moved to a new location during the delay interval without the child's knowledge.

Several measures indicate that the children were quite surprised indeed when they looked in the correct place without finding their toy. However, what proved most interesting was what they did next, particularly where they searched after looking in the right place. Striking differences in performance occurred between one group under two years of age (18 to 24 months) and another group slightly over two (25 to 30 months).

The older children generally searched in an intelligent fashion, in much the same way an adult might look for keys. After looking in the correct location, the children tended to search in places related to the original location. For example, the older toddlers looked in locations that were near the first hiding place. If the toy had been hidden under one couch cushion, they might look under the next cushion or under the couch. They also looked in what I have called analogous locations. For instance, if a pillow at one end of the couch had been the correct location, they might look under a pillow at the opposite end of the couch.

Unlike the older children, the younger ones displayed patterns of searching that were much less logical. Their searches were also far less likely to bear any relationship to the correct location.

Self-regulation

These data suggest that, by two years of age, children have become relatively flexible and logical in dealing with disconfirmed expectations.

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They are able to reflect on the situation and consider where the toy might be if it is not where they remembered. To account for its absence, they appear to consider plausible physical or mental explanations. Perhaps something happened to the toy. After not finding his toy in the desk drawer, one little boy asked, "Did Mickey Mouse fall out?" He then proceeded to search behind the desk. The older children also seem willing to consider that they might have misremembered some detail, such as exactly which cushion was the correct one.

This study shows that two-year-olds can regulate or coordinate their own actions in the pursuit of a goal, at least in some circumstances. Acquiring the capacity for self-regulation is a crucial developmental step. Finding Big Bird on any given day is not too important, but it is crucial that the child develops the ability to reflect on an unexpected outcome, re-evaluate it, and organize his or her behavior to remedy the situation.

These general abilities are referred to as self-regulatory skills, the processes by which people organize their thoughts and actions. These skills are basic to efficient thought throughout life. Transsituational, they apply to a whole range of problem-solving activities, whether you are trying to remember who the seventh President of the United States was or where you left your car keys.

Memory strategies

Apart from conducting an organized search, another important form of self-regulation related to memory involves planning ahead, doing something to facilitate later retrieval. Consider yourself in a situation where you will be called upon to remember something later, that is, to retrieve information from your memory system. To make subsequent retrieval more likely, you might engage in any number of activities that are generally referred to as mnemonic (memory) strategies. For example, you might rehearse the material by repeating it over and over.

In a series of hide-and-seek studies, Professor DeLoache has shown that young children can remember the location of objects and conduct organized searches.

You might elaborate the information to be remembered by forming a vivid mental image of it or relating it to some personal experience. Any such activities are likely to increase the amount of information that can be remembered.

Until now, such intentional mnemonic activity has never been observed for very young children. However, using the hide-and-seek format, we obtained evidence that children as young as 20 months are capable of very simple mnemonic efforts in some circumstances. In this study, we videotaped the children between the time their toy was hidden and when they were allowed to get it.

Detailed analysis of the tapes revealed that, while waiting, these young children did several things that might be construed as rudimentary memory strategies. For example, one little boy stopped playing with a toy car to look across the room at the chair behind which Big Bird was hidden. He pointed to the chair, saying, "Big Bird hiding." All of these simple behaviors — looking at the hiding place, pointing to it, and talking about it or the toy — could serve to remind the child of the toy's location. Like the adult strategies of rehearsal and elaboration, these behaviors may reinforce memory for relevant information and make its retrieval more likely.

We also found that the environment influenced whether such strategies were used. Unlike children at home, those who played the hide-and-seek game in an unfamiliar setting (a room in the Child Development Laboratory) used memory strategies more than four times as often. Presumably, remembering where an object is hidden in an unfamiliar environment is more difficult than remembering potential hiding places in a highly familiar location. Other studies in this project have led to similar conclusions.

Potential application of findings

To date, our studies have shown that very young children are capable of some simple forms of self-regulation. In one case, the two-year-olds conducted organized, logical searches; and in the other, even younger children used simple mnemonic strategies. These and other forms of self-regulation are critical cognitive skills used throughout life in a wide range of situations.

Understanding the emergence and early refinement of self-regulatory skills is also important because these skills represent one of the main areas of cognitive deficit displayed by mentally retarded people. Thus, it is hoped that what we learn about the very early development of self-regulatory skills will lead to measures for detecting delayed development at an earlier age than is currently possible.

Corn Damage From Combines

MARVIN R. PAULSEN and JOHN W. HUMMEL

Maintaining the high quality of corn is of vital importance to U.S. farmers who are competing for overseas sales. During the past few years, however, damaged corn has been the subject of increased publicity and concern. One way to minimize damage at harvest may be to use combines that cause as little damage as possible.

In a rotary combine, one or more longitudinal rotors replace the conventional cylinder, concaves, and straw walkers for threshing and separating grain from crop material. Swirled rearward by the rotor, the material passes over concave surfaces several times, but apparently with less impact than from the action of a conventional cylinder.

This study had several objectives: (1) to compare the damage to corn at three moisture levels after threshing with a conventional rasp-bar cylinder combine, a single-rotor combine, and a double-rotor combine; (2) to investigate the effect of threshing speed (cylinder or rotor speed) on corn damage for each of the three combines; (3) to determine the threshing and separating losses for each type of combine; and (4) to compare the amount of damaged corn in samples from the clean-grain auger and from the grain-tank auger.

Equipment and procedure

We tested three combines: an International Harvester 1460 Axial-Flow (single rotor), a Sperry New Holland TR-70 (double rotor), and a John Deere 7700 (conventional cylinder). All three combines were equipped with corn heads for harvesting six rows planted at 30-inch widths.

To allow sampling of grain, a small spring-loaded trap door was installed on the clean-grain auger of each combine. Canvas on a roller was attached immediately ahead of the rear wheels and unrolled for sampling losses in the crop material discharged from the rear of the combine.

Field tests were conducted on a corn plot 162 rows wide by ¼ mile long. Planted with the variety Golden Harvest 2500, the plot yielded about 116 bushels per acre. The corn was harvested in 54-row blocks on three separate days at moisture contents of 28.8, 20.3, and 18.6 percent. Three threshing speeds were randomly assigned for every 6-row pass.

All three combines were operated at 4 miles per hour. Corn samples were taken at the grain-tank and at the clean-grain augers, and losses from separating and threshing were checked. Combine settings for two harvest dates, represented by the highest and the lowest moisture levels, are shown in Table 1.

Several tests were used to analyze the corn samples: (1) breakage percentages, (2) fast green dye tests for pericarp damage, (3) percentage of stress cracks in whole kernels, and (4) warm and cold germination tests.

Results

Broken corn. In samples from both augers, corn breakage ranged from 0.22 to 0.92 percent (Fig. 1). Averaged over all moistures, combines, and threshing speeds, breakage was 0.52 percent at the tank auger and 0.44 percent at the clean-grain auger. For the two rotary combines, regardless of corn moisture content, breakage at the tank was not significantly greater than at the clean-grain auger. For the conventional combine, but only in corn with 20.3 percent moisture, the percent breakage was significantly higher in tank samples than in clean-grain auger samples for the slow and medium cylinder speeds.

At the two highest moisture levels,

Table 1. — Combine Threshing Speeds,[a] Peripheral Speeds, Concave Clearances, and Cleaning Fan Speeds for Two Harvest Moistures

	Conventional cylinder		Single rotor		Double rotor	
			28.8 percent moisture			
Threshing speed level	*rpm*	*fpm*	*rpm*	*fpm*	*rpm*	*fpm*
Slow	430	2,480	350	2,200	510	2,260
Medium	525	3,010	450	2,830	610	2,720
Fast	625	3,600	550	3,460	710	3,170
Minimum concave clearance, in.	1.25		1.14		1.38	
Cleaning fan, rpm	925		900		900	
			18.6 percent moisture			
Threshing speed level	*rpm*	*fpm*	*rpm*	*fpm*	*rpm*	*fpm*
Slow	350	2,030	300	1,890	520	2,300
Medium	450	2,600	385	2,420	650	2,890
Fast	550	3,170	475	2,970	750	3,350
Minimum concave clearance, in.	1.50		1.14		1.30	
Cleaning fan, rpm	925		770		975	

[a] Threshing mechanism diameters: conventional cylinder = 22 inches; single rotor = 24 inches; double rotor = 17 inches.

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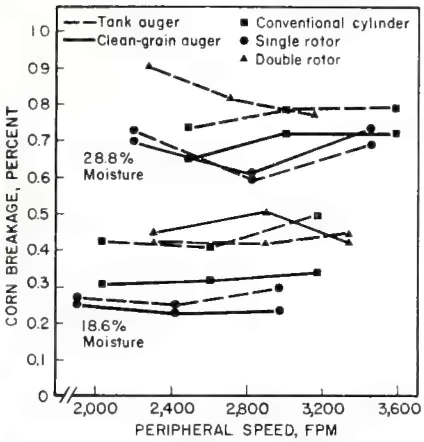

Corn breakage in auger samples in relation to peripheral cylinder and rotor speeds. Breakage is defined as the percentage of corn passing through a sieve with 12/64-inch round holes. (Fig. 1)

Table 2. — Separating and Threshing Losses for Each Combine

Threshing speed level	Losses, bushel per acre		
	Conventional cylinder	Single rotor	Double rotor
28.8 percent moisture			
Slow	0.12	0.11	0.22
Medium	0.44	0.17	0.32
Fast	0.38	0.20	0.13
20.3 percent moisture			
Slow	0.28a[a]	0.14	0.44a
Medium	0.16ab	0.19	0.33ab
Fast	0.09 b	0.21	0.24 b
18.6 percent moisture			
Slow	0.56	0.10	0.39
Medium	0.09	0.12	0.23
Fast	0.13	0.20	0.36

[a] Numbers with different letters within columns and moisture levels differ significantly at the 5-percent level based on an LSD test for differences between means.

no significant differences in breakage were found for the various combines or threshing speeds. At the lowest moisture level, breakage for tank samples from the single-rotor combine averaged 0.25 to 0.30 percent, depending on rotor speed. For the other two combines, breakage was 0.40 to 0.49 percent when all speeds were compared.

Samples from the clean-grain auger of the single-rotor combine had significantly less breakage than did samples from the double-rotor machine at the lowest moisture level. However, for the conventional combine, corn breakage was not significantly different from that of the other two combines for samples from the clean-grain auger.

Threshing speed affected breakage in the tank samples at the 18.6 percent moisture level. The single-rotor and conventional cylinder combines produced a significantly greater amount of breakage as the speed increased from medium to fast. Under the same conditions, a small but not significant increase in breakage occurred for the double-rotor combine.

Fast green dye tests. At 28.8 percent moisture, these tests for severely damaged kernels from the clean-grain auger revealed damage ranging from 11 to 12.1 percent. At 18.6 percent moisture, the damage was considerably less, ranging from 4.3 to 6.5 percent.

Fast green dye analyses indicated that the peripheral threshing speed had no significant effect on the extent of severe damage. However, at the 20.3 percent moisture level and fast threshing speed, the percentage of severe damage was less in clean-grain auger samples from the conventional cylinder combine than from the double-rotor combine. At the lower speeds and the other two moisture levels, the differences in severe damage among combines were not significant.

Stress cracks. The mean percentages of stress cracks in whole kernels ranged from 0 to 10 percent. Variations in threshing speed and combine design caused no significant difference in these percentages.

Germination tests. Warm and cold germination percentages for samples from the clean-grain auger did not vary significantly with threshing speed or type of threshing mechanism. However, warm germination percentages for tank-auger samples at 18.6 percent moisture did vary by sampling location. Cold germination percentages for tank-auger samples at all moistures were significantly lower than for samples from the clean-grain auger.

Losses. Composite separating and threshing losses normalized to 15.5 percent moisture varied widely, ranging from 0.09 to 0.56 bushel per acre (Table 2). No significant differences were found among combines at any of the moisture levels tested. However, at 20.3 percent moisture, the conventional cylinder and the double-rotor combines each had significantly lower mean losses at the highest than at the lowest threshing speed. In the single-rotor combine, mean losses tended to increase, but not significantly, as threshing speed increased.

Conclusions

Several conclusions can be drawn from these test results:

- In field tests, breakage for Golden Harvest 2500 corn was less than 1 percent for all three combines at all the harvest moistures and threshing speeds tested.
- Threshing speeds within the ranges tested significantly affected corn breakage only at the lowest moisture level.
- Breakage was similar for all three combines at the two highest moisture levels. At the lowest level, the single-rotor combine produced less breakage in the tank samples than did the other two combines. In samples from the clean-grain auger, the single-rotor machine produced less breakage than did the double-rotor combine, but in every case breakage was less than 1 percent.
- Fast green dye tests indicated that damage was more severe at 28.8 percent moisture than at the lower levels. Severe damage did not differ appreciably with the threshing speeds tested.
- Composite separating and threshing losses did not differ significantly among combines, but at 20.3 percent moisture the losses for the conventional cylinder and double-rotor combines decreased as the cylinder or rotor speed increased.
- Corn breakage and damage were at an acceptably low level for all three combines. Separating and threshing losses were also within acceptable limits for the corn variety and harvest conditions tested.

Sewage Sludge on Vegetables —A Mixed Blessing

J. M. GERBER, J. M. SWIADER, and T. R. PECK

IN RECENT YEARS, some gardeners have been using municipal sewage sludge as a fertilizer. Although processed sludge provides valuable plant nutrients and improves soil structure, repeated use cannot be recommended. It now appears that the heavy metals in some sludge may be hazardous to human health.

Used as a soil amendment, sludge helps to improve the yields of certain vegetables grown in sandy soils (*Illinois Research,* Spring, 1978, pp. 12-13). Because these soils drain excessively and have a low cation-exchange capacity, some nutrients leach rapidly. Without sludge, large amounts of fertilizer or several applications are required if producing vegetables is to be economically worthwhile. With sludge, however, the nutrients added to sandy soils are held better and the water-holding capacity is improved.

1980 yield studies

But does sludge, and particularly some of the heavy metals in it, have a residual effect on yields? Last year a study was conducted to try to answer this question. We grew six vegetable crops in the same Plainfield sand used in earlier studies, but with some modification in the three fertility regimens:

1. In the check plot, where no fertilizer had been added since 1974, 50 pounds of nitrogen per acre was broadcast and incorporated before planting in 1980. Another 50 pounds was sidedressed at midseason.
2. In the plot treated with inorganic fertilizer, nitrogen, phosphorus, and potash had been applied annually at the rate of 120, 60, and 60 pounds per acre, respectively, from 1974 through 1978. In 1980 these fertilizers were again broadcast and incorporated before planting, and a midseason sidedressing was applied for a total of 100, 60, and 60 pounds.
3. In the sludge-amended plot a liquid sludge, which had been anaerobically heated and digested, was applied from 1974 through 1976. The following two years a heat-dried sludge was used. Application rates were adjusted to provide 300 pounds of nitrogen per acre during each of the five years. From 1976 through 1978 potassium and magnesium were also added to correct deficiencies. In 1980, 50 pounds of nitrogen was broadcast and incorporated before planting, and an additional 50 pounds sidedressed at midseason.

The crops were Vates kale and collards, Golden Acre cabbage, Pik-Red tomatoes, Dusky eggplant, and California Wonder peppers. The kale and collards were direct-seeded; the others were transplanted. Each of the vegetables, including two replications, was planted in a 45-foot row in all three plots. Irrigation and standard pest control methods were used.

The 1980 fertility status of the Plainfield sand is summarized in Table 1. In the sludge-amended plot soil nutrient levels remained high even though no sludge had been applied for two years. Phosphorus and magnesium levels were higher than those recommended for vegetable crops grown in sandy soils. Potassium levels were also markedly higher. However, the most significant difference among the three plots was in cadmium concentration, which was determined by a 1N HCl extraction. The high concentration and the persistence of cadmium in the plow layer several years after sludge application indicate that cadmium and possibly other heavy metals are prime constituents of the sludge material used.

Vegetable yields are summarized in Table 2. Application of sludge increased the yields of all six crops

Table 1. — Soil Analysis for Three Treatments of Plainfield Sand, 1980[a]

Soil treatment	pH	Phosphorus	Potassium	Calcium	Magnesium	Cadmium
			lb/A			ppm
Check	7.1	58	56	800	136	0.25
$N\text{-}P_2O_5\text{-}K_2O$, 100-60-60	6.2	104	132	560	112	0.20
Sludge	6.5	250+	208	920	328	11.00

[a] Data represent composite samples taken at midseason.

Table 2. — Vegetable Crop Yields for Three Soil Amendment Regimens in Plainfield Sand

Soil treatment	Yield, tons/A					
	Collard	Kale	Cabbage	Eggplant	Pepper	Tomato
Check	6.3	4.4	7.3	1.7	1.6	12.2
$N\text{-}P_2O_5\text{-}K_2O$, 100-60-60	8.6	6.6	10.4	1.6	2.0	16.1
Sludge	21.2	18.4	24.0	2.6	2.3	20.2

J. M. Gerber is Extension specialist in vegetable crops and assistant professor of horticulture; J. M. Swiader, assistant professor of horticulture; and T. R. Peck, professor of soil chemistry, Department of Agronomy. G. R. Stack and members of the Chicago Urban Gardening Program helped to collect samples for analysis.

tested, but the increase for the leafy vegetables in particular was striking. The marketable yields of cabbage, kale, and collards increased three to five times; the increases for tomatoes, peppers, and eggplants were slightly less.

The large growth response of the leafy vegetables suggests that sewage sludge might be a potential source of residual nitrogen for sandy soils. With the inorganic fertilizer treatments, the yields were only slightly greater than those in the check plots, thus indicating that the 120-60-60 recommendation is inadequate for vegetable production on this soil.

Two years after final application, the beneficial effects of sludge were still in evidence, but so were the high levels of soil cadmium. To determine the extent of plant uptake of cadmium, vegetable tissue analysis was required. A second study was conducted to establish the relationship between soil cadmium and plant uptake in garden vegetables.

Chicago garden survey

The first step was to collect random soil samples from 61 gardens, some of them sludge amended, in the Chicago area during the spring of 1979. The samples were analyzed for acidity, soluble salts, lead, phosphorus, potassium, and cadmium. With the 1N HCl extraction procedure, nearly all cadmium in the soil can be removed.

Depending on cadmium level, the garden samples were put into one of two groups: those without sludge and having cadmium levels of less than 5 parts per million (ppm); those with sludge and levels exceeding 5 ppm. In the latter group, the levels ranged from 5.5 to 103.5 ppm. Applications of sewage sludge had clearly raised the soil cadmium above the normal level. The question remained whether the excess cadmium would accumulate in the edible parts of vegetables grown on these soils.

The second step in our study was to return to the gardens later that summer and gather both plant and soil samples. This time the soil was collected from the rooting zone of the plant being sampled. The fresh plant samples were washed or peeled the way a consumer would prepare them. They were then frozen and stored until they could be oven dried at 175° to 195° F, ground in a Wiley mill, and analyzed for cadmium.

Table 3. — Cadmium Concentrations in Edible Parts of Vegetables From Chicago Gardens

Crop	Mean cadmium, ppm[a]	No. of samples	Pct. samples with more than 1 ppm cadmium
Collard	4.0	10	80
Lettuce	3.7	12	75
Beet top	3.4	21	81
Beet root	1.8	19	53
Onion	1.7	12	58
Ripe tomato	1.6	14	50
Carrot	1.3	13	38
Pepper	1.2	22	59
Green tomato	1.0	35	40
Bean	0.9	34	29
Squash	0.7	10	20
Cucumber	0.7	16	25

[a] A steady diet of vegetables with more than 1 ppm cadmium on a dry weight basis is generally not recommended.

Plant concentrations of cadmium on a dry weight basis are presented in Table 3. The edible parts of collards, lettuce, and beet tops contained high levels of cadmium, while fruit crops such as cucumber, squash, tomatoes, and peppers contained much lower levels.

More cadmium was believed to accumulate in the edible parts of leafy green vegetables than in seed, fruit, or root crops. Our study confirms that observation.

Limitations of soil test

In order to use soil test results as a predictor of cadmium uptake by plants, there must be some relationship between soil and plant concentrations. However, we found almost no relationship between cadmium levels in the soil and in the plant.

Until now it has been recommended that vegetables not be consumed if soil cadmium levels exceed 5 ppm. But the recommendation implies that a relationship exists between soil test levels of cadmium and plant uptake. Unfortunately, the matter is not so simple. Other factors such as pH, soil phosphorus and zinc, the chemical form of cadmium, plant type, and growth rates also affect the accumulation of cadmium in the plant.

Studies have shown that when the only variable is the level of soil cadmium, a relationship does exist between soil and plant cadmium. Given a single crop grown at one location, the soil test for cadmium may have some value. But when many soils, crops, and garden practices were examined, there was no meaningful relationship between soil and plant cadmium. In fact, 44 percent of the samples of leafy greens were grown on soil with less than 5 ppm cadmium, yet they had more than 1 ppm in the edible parts. Clearly we cannot rely on a soil test level of 5 ppm. Additional research is needed to find a soil test that is a better predictor of plant uptake.

Recommendations

Gardeners who have applied sludge in the past but have left it on the surface are advised to mix it thoroughly with the soil to a depth of about 8 inches. Incorporation will help dilute the available cadmium. Soils should be limed to pH 7 and fertilized with phosphorus to a soil concentration of about 100 pounds per acre to reduce the amount of cadmium available for plant uptake. Gardeners are also advised not to grow leafy green vegetables in areas that have been sludge amended within the previous three years.

Sludge cannot be recommended for lawns or flower beds if they are to be converted to vegetable gardens in the near future. However, sludge is probably safe when applied to ornamentals, turf, and reforested, strip-mined lands. Applications at recommended rates are also acceptable on field corn and soybeans, since little cadmium accumulates in seed.

Until a method of treatment is developed to remove potentially hazardous heavy metals from sewage waste, sludge should not be applied to vegetable gardens or commercial vegetable acreage.

Agricultural Research: Who Pays for It?

ROBERT JUDD

COMMERCIAL FIRMS, as well as private and public institutions, conduct agricultural research in this country. Ultimately, everyone who eats shares the expense and receives the benefits of research. In the United States these benefits are especially impressive. Food takes proportionately less of our disposable income than in any other country.

Although commercial companies finance their own research and develment activities, the expense is finally borne by the consumer. The farmer-consumer, for example, pays for part of John Deere's research and development when he buys a green and yellow planter.

A few private organizations, other than those that manufacture products, conduct some agricultural research. The Charles F. Kettering Foundation, the Battelle Institute, and the Stanford Research Institute are examples. With the equipment, the facilities, and capable scientists at their disposal, this type of organization is able to do excellent research. However, their share of the agricultural research effort is relatively small.

Federal research funds

A third category to consider is public agricultural research institutions, namely, federal and state. Agricultural Research is the agency that conducts federal research under the Science and Education Administration of the U.S. Department of Agriculture (SEA-USDA). Most of this agency's scientists work at land-grant institutions or federal regional centers.

Cooperative Research, also under SEA-USDA, is the agency that administers federal funds for the experiment stations at each land-grant institution. These stations are the state agencies that conduct agricultural research. The University of Illinois at Urbana-Champaign, Purdue University, and Iowa State University are examples of institutions that have state experiment stations.

Let's look at who provides the budget for these public institutions. The SEA Agricultural Research agency is financed by direct appropriations from Congress. One to two years before the budget is prepared, the deputy Agricultural Research administrators who are closest to scientists in the field develop budgets that will meet their program objectives. The Agricultural Research administrator in Washington then groups these budgets into a composite, which is submitted to the director of SEA and eventually to the Secretary of Agriculture.

SEA's Cooperative Research agency, after receiving input from the agricultural experiment station directors, also prepares a recommended budget. The process is completed for Cooperative Research just as for Agricultural Research.

The President of the United States then takes the recommendations of the Secretary into consideration, along with all other budgetary needs, and recommends a top-dollar allocation to the Secretary of Agriculture. The Secretary decides how much of that allocation will go to Agricultural Research, Cooperative Research, Extension, and so forth. These allocations often bear little resemblance to the budget needs expressed by the working scientists.

After the President submits his budget to the Congress, the House and Senate subcommittees on agricultural appropriations hold public hearings so that interested parties can present their views on the budget recommendations. Anyone from A to Z — apple to zucchini growers — can testify, as I have done since 1961 for more research funds for agriculture in general and for soybean production in particular. In 1960 the funds for soybean production research were less than $500,000; today they are about $8 million.

Each subcommittee works all of these inputs into its version of an agricultural appropriations bill. After considerable compromise, the entire House and Senate approve an appropriations bill. The last step is for the President to sign the bill.

Experiment station funds

Now let's get close to home and look at the sources of funds that enabled the University of Illinois to operate its Agricultural Experiment Station in fiscal 1979:

	million dollars
Cooperative Research (Hatch Act)	3.9
Federal grants	1.3
State appropriations	7.1
Sale of research residues	1.8
Industry grants, gifts, agreements	1.1
Other nonfederal	0.5
Total	15.7

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The paper this article is based on appeared in the "1980 Illinois Fertilizer Conference Proceedings." Recently updated, the information is presented here to give our readers some idea of the complex political process by which state agricultural experiment stations receive their funds.

Here is a comparison of the Illinois Agricultural Experiment Station budget with the budgets of some other north central states for 1979:

	million dollars
Illinois	15.7
Iowa	18.2
Ohio	19.5
Indiana	21.3
Wisconsin	24.6
Michigan	25.0

Of the experiment stations in the twelve midwestern states, only those in Missouri, North Dakota, and South Dakota had lower budgets than this state. Illinois also ranked ninth among the twelve in support by state appropriations. Minnesota's state legislators provided $16 million for their experiment station, compared with $7 million for Illinois.

In total value of farm sales, Illinois ranks among the top five of the fifty states. Just think how much greater the value could be if we had more research to boost yields. Even Georgia and North Carolina taxpayers allocate more than twice as much as Illinois taxpayers to their experiment stations.

To make the point another way, let's look at the additional tax revenues that can be generated by an increase in Illinois corn and soybean production:

Soybeans

3-bushel per acre increase
9 million acres = 27 million bushels at $7 per bushel = $189 million

Corn

10-bushel per acre increase
11 million acres = 110 million bushels at $3 per bushel = $330 million

Total increase

$189 million + $330 million = $519 million

Additional tax revenue

$519 million at only 5 percent = $26 million

The $26 million additional revenue generated in Illinois in this example is more than three times the state legislature's total research investment. Nationally there is a 35 to 50 percent annual return on the investment in agricultural research. Research is clearly an unwise place to cut expenditures, but our legislators tend to ignore the importance of this investment.

Benefits from research

Who will pay for the lack of adequate research funds? All consumers and taxpayers, not just farmers, will bear the cost of unwise cuts, and sooner than we realize. Without a sound agricultural research base, the overall economy will suffer. The economy needs agriculture for several major reasons:

1. A favorable balance of trade is maintained through the sale of our agricultural products.
2. Millions of jobs depend on the production, processing, distribution, and retailing of agricultural products.
3. Additional taxes from profitable farms make a sizable contribution to state and federal incomes over and above paying for the research investment.
4. The relatively low proportion of our disposable income spent for food allows consumers the latitude to purchase other commodities or to save.

If we are to meet domestic and foreign demands in the year 2010, each acre of agricultural land must produce twice as much as it does today. Only research can make this level of productivity possible.

Unfortunately, there are fewer production researchers now than fifteen years ago. The well for basic research started drying up in 1967. This downward trend has continued since then because budgets did not keep pace with inflation and the demands for environmental protection. As a result, the scientists in applied research have less and less new knowledge for improving farming practices.

After a significant decline of funding during the past several years, agriculture's share was only 2 percent of all government research and development funds in the final fiscal 1981 appropriations. The $620 million for Agriculture was dwarfed by the $16 billion for Defense, $5.5 billion for the National Aeronautics and Space Administration (NASA), $3.7 billion for the National Institute of Health (NIH), $3.4 billion for Energy, and $1.1 billion for the National Science Foundation (NSF). Even Commerce with an appropriation of $872 million received more than Agriculture.

Role of leaders

We in agriculture and related industries have an important task. We must inform target audiences that the need for agricultural research is critical. Let me suggest that the most efficient way to let people know is by educating our legislators. We must help them realize that food costs and availability are a daily concern to everyone. We must stress consumer benefits from an adequate food supply. We must also indicate that agricultural industries will support those legislators who back increased research funding. Without a funding increase, the future of agriculture could be grim.

But the news is not all bad. Our leaders are beginning to realize that the energy crisis of the 1970s will be replaced by the food crisis of the 1980s. A new awareness of the vital importance of food, feed, and fiber production in this country is surfacing among our leaders.

The National Agricultural Research and Extension Users Advisory Board has taken a firm stand on the research issue. In its first report, presented to the President, the Secretary of Agriculture, and Congress in the fall of 1979, the organization gave top priority to halting the erosion of state and federal support for basic agricultural research. Their second report in October, 1980, stated that the first priority of U.S. agriculture should be to maintain the stability and productive capacity of the resource base.

Rather than asking who pays for agricultural research, we need to know who benefits. The answer is simple: everyone who eats. Let's keep telling our story lest the legislators forget.

University of Illinois at Urbana-Champaign
Agricultural Experiment Station · R. G. Cragle, Director
Urbana, Ill. 61801 · Publication · 11,500

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FARM BUSINESS TRENDS

Responding to high government support prices, U.S. milk production in 1980 hit a record 128.4 billion pounds, an increase of 4.1 percent over 1979. Further increases are expected in 1981. Expanded output has been due in part to the stabilizing of cow numbers, which declined by about half between the early 1950s and 1977. By 1980, average production per cow was double that of 25 years ago.

Although the recent surge in milk production has interrupted the long-term downward trend in some states such as Illinois, the pattern has varied geographically. The largest increases have occurred in the West, particularly in California. Except for Wisconsin and Michigan, the proportion of the nation's milk produced in Illinois and other midwestern states has been declining.

Commercial sales of dairy products other than cheese have not expanded along with milk production. Long-term declines in per capita consumption of fluid milk products and butter, although perhaps slackening in recent years, continued through 1980. Much the same has been true for the consumption trends of evaporated, condensed, and nonfat dry milk. Consumption rates of frozen dairy products have changed little during the past decade. Moreover, per capita consumption of cheese declined slightly in 1980 after a steady rise during the 1970s.

Under these conditions, the U.S. Department of Agriculture has greatly expanded its purchases of dairy products under the price support program. In 1980 the government removed about 7 percent of the total dairy products marketed. By February 1, 1981, government stocks of surplus dairy products included nearly 300 million pounds of butter, 200 million pounds of cheese, and 500 million pounds of nonfat dry milk. In the marketing year that ended September 30, 1980, the net cost of the dairy support program was practically $1.3 billion.

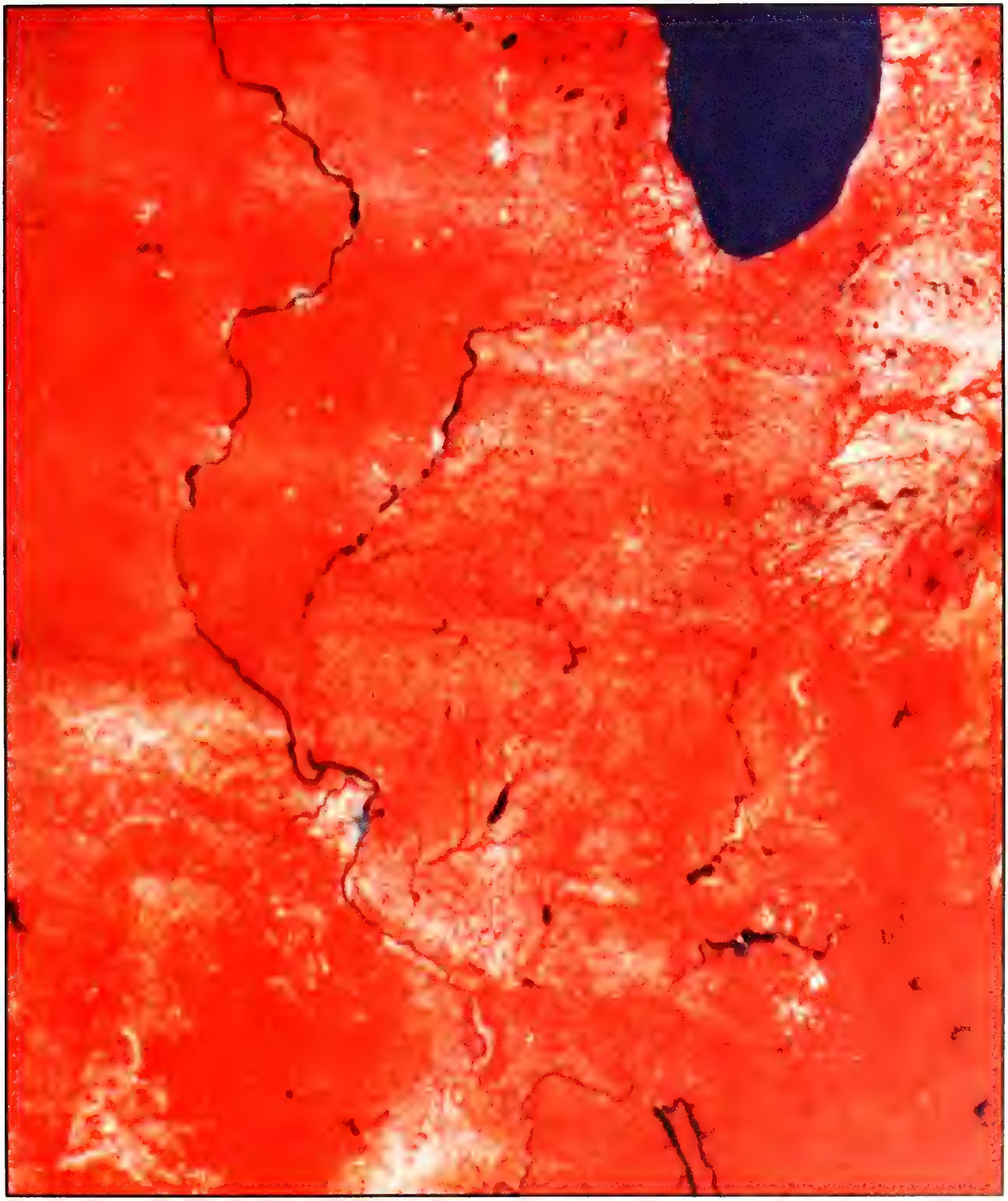
The high government support prices for milk have been reflected in sharply higher net incomes of dairy farmers. Since last summer, however, increases in grain prices have reduced the milk-feed price ratio below the favorable levels of the late 1970s and early 1980. (The ratio shows the pounds of 16-percent protein dairy ration equal in value to one pound of milk.) The decline in this important indicator of the profitability of dairying will be accentuated if the price of grain increases further or if price supports are reduced on October 1, 1981.

The outlook for dairying depends on decisions about the level of price supports and on trends in commercial sales of dairy products. If continued, high support prices would help in the near future to maintain dairymen's incomes at high levels, but would have an adverse effect on commercial sales. With lower support prices, income levels of dairymen would be expected to drop, and would depend heavily on factors such as consumer buying power and meat prices, both of which influence commercial sales of dairy products.

Unless price supports are maintained at high levels, dairying in Illinois will probably continue to decline. The Chicago regional federal order market is burdened with large quantities of excess milk. This surplus limits possible increases in blend prices in all of Illinois's fluid milk markets. The state's dairy manufacturing industries have shrunk to insignificance except for limited production of cheese in northwestern Illinois and production of frozen dairy products and cottage cheese for local markets. — *Sheldon W. Williams, professor of agricultural economics*

Illinois Research

Agricultural Experiment Station
Summer/Fall 1981



College of Agriculture, University of Illinois at Urbana-Champaign, Volume 23, Numbers 3/4

With great expectation, we launch a new era in reporting Illinois agricultural research. The Agricultural Experiment Station has long needed a way to comprehensively express concerns and accomplishments, and to routinely discuss research as it relates to the future of Illinois agriculture. It is our hope that the changes being made in *Illinois Research* reporting will fulfill these goals.

We embark on this new venture with a transition issue that reflects on the Agricultural Experiment Station and its long-standing place in research, extension, and teaching programs in agriculture. Over the years, people with a vision of the future have made impressive contributions to agricultural research at the University of Illinois. At a time unlike any in the past, we too must envision the future.

We now recognize the fragile balance between our resources, their use, and the environment. We have become aware of the enormous advances in the technology of measuring devices and communications. We see many familiar aspects of societal growth giving way to new and unfamiliar dimensions of growth. *Illinois Research* must be at the forefront of these changes, weaving them together in a probing, searching way that will meet the needs of the public.

In *Illinois Research* we will attempt to look five to ten years into the future. We will do this from the strong base of accumulated knowledge and from a proud tradition. Through these efforts we hope to come to a better understanding of the use of our research talents, our work spaces, and our research tools.

In future issues we will try to capture some of the breadth and excitement of the intellectual ferment taking place in the College of Agriculture and in the Agricultural Experiment Station.

Orville G. Bentley
Dean, College of Agriculture

Raymond G. Cragle
Director, Agricultural Experiment Station

The Cover

The mosaic of Illinois was produced by computer from scanning data gathered by Landsat satellite at a height of 570 miles. The 23 separate images, each representing an area roughly 115 miles square, were often made on different dates, thus causing a mismatch of image density. In this picture, green vegetation appears red or pink; yellowing vegetation, very light pink; soil, brown (wet soil being a darker brown); and water, dark blue. Cities are lighter pink than the surrounding agriculture land. Rockford can readily be seen near the northern edge of Illinois. Much of the state is bordered by water: Lake Michigan in the northeast, the Wabash River to the southeast, the Ohio River in the south, and the Mississippi River to the west.

Illinois Research

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From Humble Beginnings . . . . A New Confidence

For nearly a hundred years Illinois has had an Agricultural Experiment Station. Under the federal Hatch Act of 1887, which provided for the establishment of experiment stations across the country, the Illinois Station was created in 1888. The first annual appropriation to Illinois was $15,000, one-fifth of which by law could "be expended in the erection, enlargement or repair of a building or buildings necessary for carrying on the work. . . ."

The University of Illinois had been founded just 21 years before then, with John Milton Gregory as its first head but with no regular professor of agriculture. The first student was graduated from the newly formed College of Agriculture in 1872. By 1888 a total of only 37 students had graduated in agriculture.

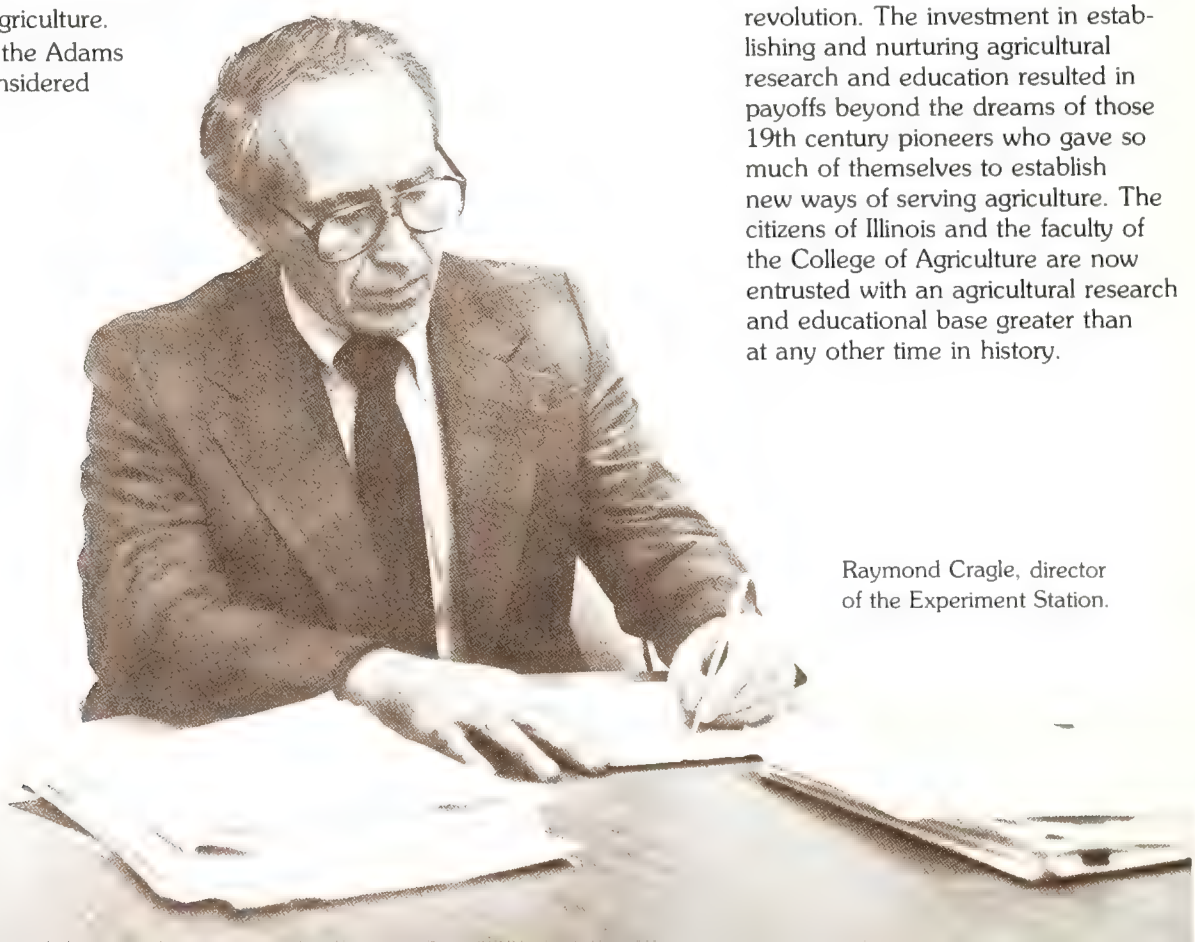
In 1906 through the Adams Act, Congress reconsidered the funding for agricultural experiment stations. Over the next six years, annual funding was increased, reaching a total of $30,000 per year in 1911. The College of Agriculture graduated 21 students in 1906, bringing the total to 122 since the first certificate was awarded 34 years before.

It is obvious that agricultural research and education had humble beginnings in Illinois. Mutually supportive in the land-grant system, research and education were needed to develop an Agricultural Experiment Station, a job that took much time. Through those early years the influence of the College on farm practices in Illinois was not as great as might have been expected.

Most of the years after 1910 were spent building scientific societies, bodies of research literature, faculties, and laboratories. At the end of World War II, veterinary medicine became a college in its own right, but continued to work with the Experiment Station and the Cooperative Extension Service.

During the building process in the first half of the 20th century, benefits began to flow at an increasing rate to agriculture and to the general public. From an agricultural base established before World War II, we emerged into a post-war era with a new confidence in science and on a much stronger footing in economics and human talent.

The 36 years since World War II have been a period of agricultural revolution. The investment in establishing and nurturing agricultural research and education resulted in payoffs beyond the dreams of those 19th century pioneers who gave so much of themselves to establish new ways of serving agriculture. The citizens of Illinois and the faculty of the College of Agriculture are now entrusted with an agricultural research and educational base greater than at any other time in history.



Raymond Cragle, director of the Experiment Station.

But what about tomorrow?

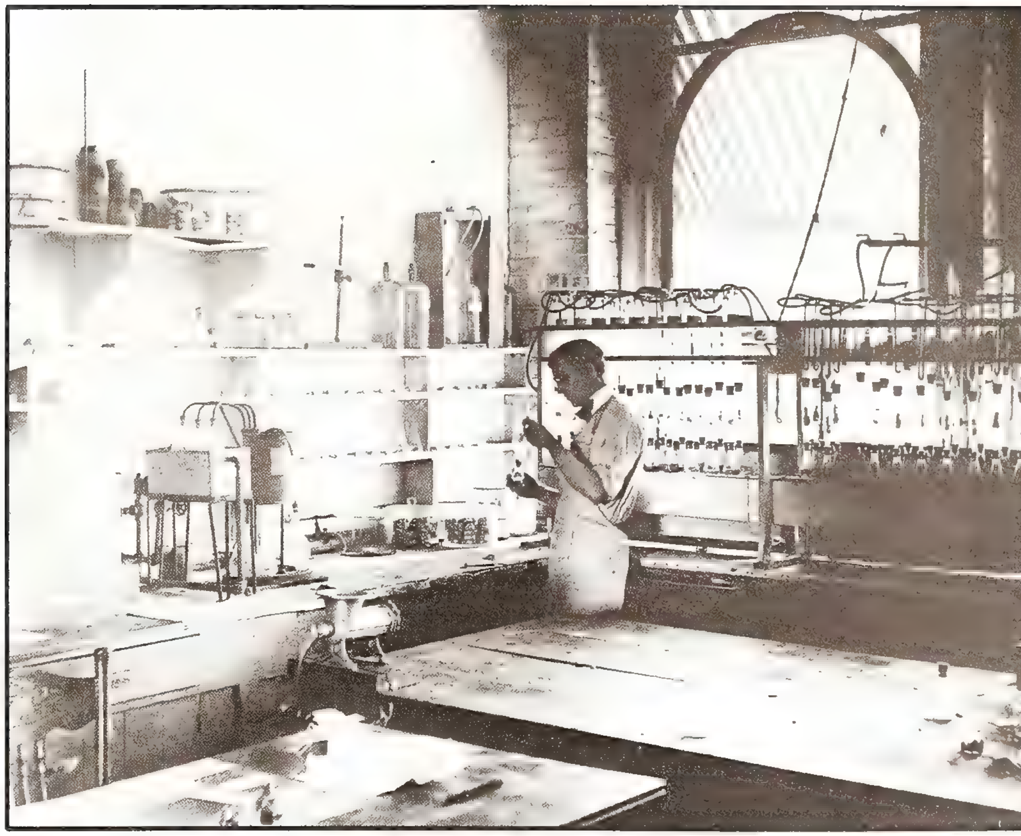
Roger Bacon, a 13th century Franciscan friar who advocated the repetition of experiments until there could be no reasonable doubt, has been described as a prisoner of medieval thought. In the very early years of the Illinois Agricultural Experiment Station, faculty members were also prisoners, but of inadequate facilities, funding, and staff size. In more recent years our prisons have taken on other guises. It would be well for those of us in the Station today to examine the nature of our own prisons.

With the best faculty, supporting staff, laboratories, and funding ever found in the Station, will it be said someday that we were prisoners because we did not build the research teams needed for solving comprehensive problems and failed to understand the nature of the problems and opportunities that characterize the 1980s? Will it be said that we should have pursued narrower subjects in greater depth or that we lacked imagination and failed to enlist other members of society into developments the Station could not accomplish alone?

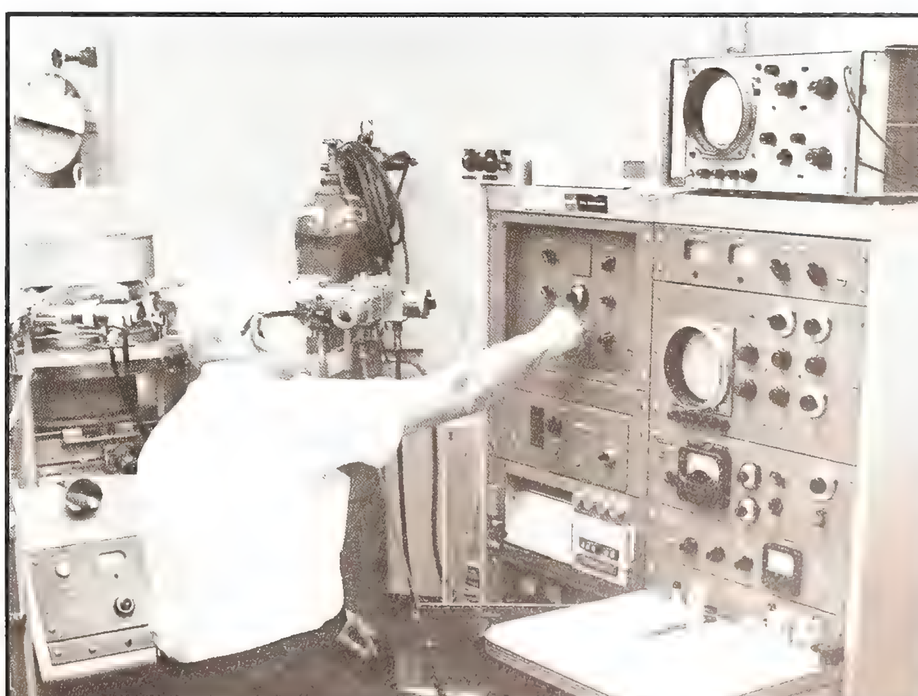
These are the self-imposed queries we are asking about the future of agricultural research. This questioning, searching attitude will be the underlying tenet for the new *Illinois Research*.

In a world in transition toward using renewable resources to meet the needs of a still growing population, agriculture has a formidable task. That task takes on even greater dimensions if we accept a social responsibility for sustaining the agricultural production base despite the stresses of today's intense agricultural production practices.

Raymond G. Cragle, director, Agricultural Experiment Station



Three-quarters of a century ago, scientists in Davenport Hall, the old agriculture building, worked in laboratories that would be considered primitive in the 1980s.



Today, sophisticated instruments like this mass spectrometer, operated by Everett Mayhood, are standard equipment in food research at the Burnsides Laboratory.

Letters

In the public interest

To the Readers:

We need your input so that Illinois Research *can serve as a forum for the exchange of ideas between scientists and users of the knowledge generated by the Agricultural Experiment Station. Through the new "Letters" column we invite our readers to raise questions and make comments about the work of the Station and the information appearing in* Illinois Research.

Letters to the editor should be relatively brief, legible, and signed. We will select letters for publication on the basis of timeliness, clarity of presentation, and the space available in the "Letters" column. All sides of an issue will be printed, provided letters meet the criteria for publication.

Scientists in the research network welcome reactions from the people they serve. Anyone with questions and observations is encouraged to send them to us.

Sheila A. Ryan, editor

Address communications to Editor, Illinois Research, 123 Mumford Hall, 1301 West Gregory Drive, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801

Please limit letters to 250 words.

Antioch to Unionville and Carthage to Sidell

The Agricultural Experiment Station operates throughout Illinois — in University facilities, in factories and farmers' fields, in cities and suburbs, on the highways, in forests, and on the lakes and streams.

Andrew Sloan Draper, president of the University of Illinois in the late 19th century, stated that "The wealth of Illinois is in her soil, and her strength lies in its intelligent development." This theme inspired many of the pioneers of agricultural science to initiate projects to study the production potential of Illinois agriculture and to improve the management of this, the state's greatest resource.

With its mission to "conduct original researches or verify experiments" in the broad area of agricultural science, the Experiment Station carries on much of its work in University-owned laboratories and fields, most notably on and near the campus at Urbana-Champaign. These campus facilities are diverse, relatively extensive, and still growing. The total floor space in offices and laboratories equals almost 10 acres, and the field research facilities on the South Farms now occupy more than 2,000 acres.

In response to the implacable demand for space in which to carry on increasingly complex investigations, and with the support of a package of capital development programs called "Food for Century III," major new or remodeled facilities are in use or under construction. Among these are the Agricultural Engineering Sciences Building (which includes space for Agricultural Engineering, Forestry, and Food Science), the veterinary research farm buildings, the dairy farm modernization project, the Meat Science Laboratory, and the Swine Research Center expansion project. Also new or under construction are the Swine Progeny Testing Facility, and expansion of the U.S. Department of Agriculture soybean facilities.

From its beginning, the Experiment Station has been guided by the concept of serving all the people of the state, responding to the needs of agriculture, agribusiness, homemakers, and citizens wherever they may be in Illinois. Thus many of the Station's investigations are conducted elsewhere in the state and even beyond.

Illinois is about 400 miles long and 200 miles wide at its widest point

The Morrow Plots, surrounded by buildings on the University of Illinois campus, are a century-old lesson in soil management and crop production.

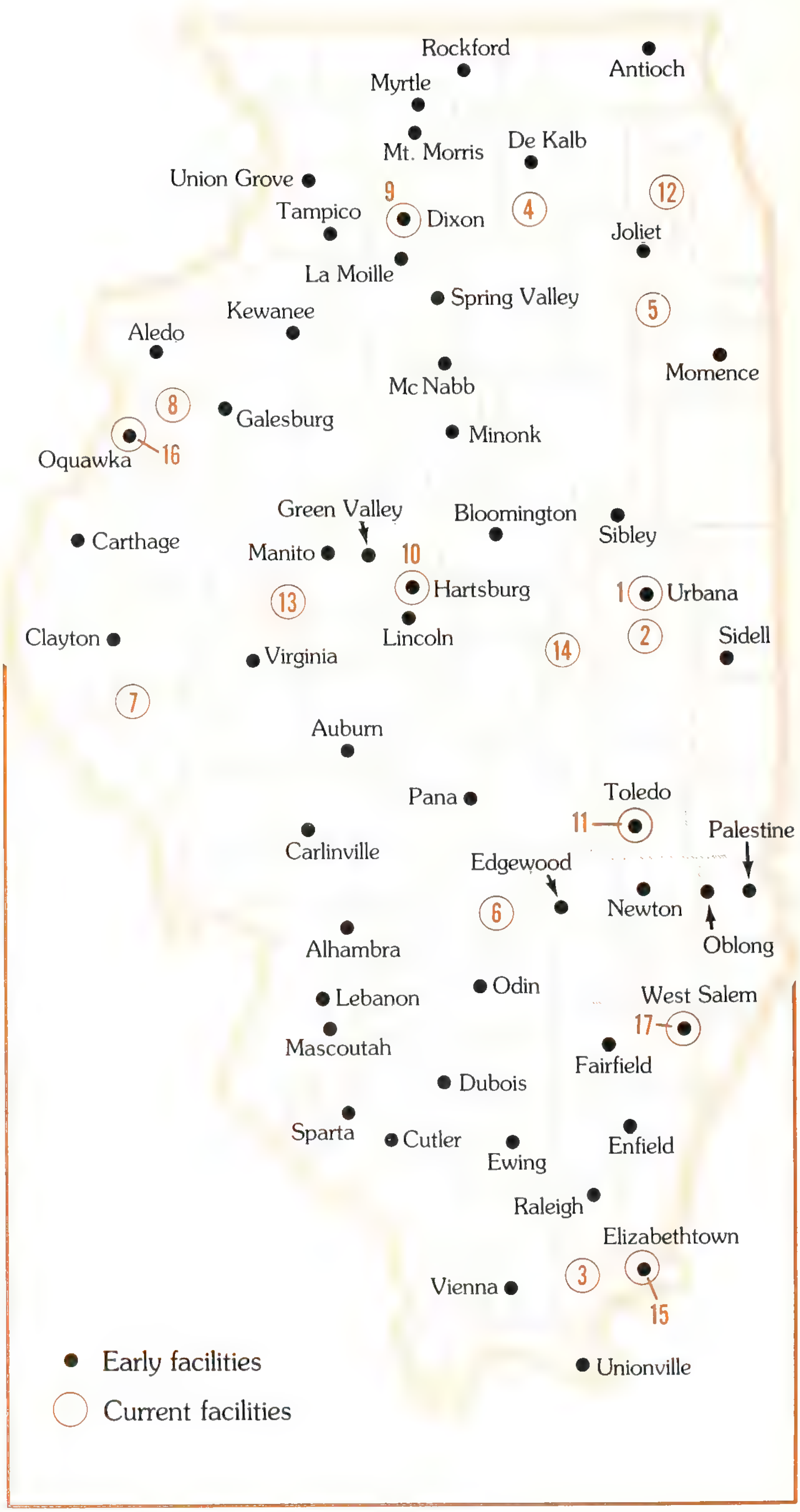
and contains more than 56,000 square miles. Not only is it a relatively large state, it is also quite variable in climate, topography, and soil productivity. Since this variability affects agricultural production, research has to be carried on wherever unique conditions demand it.

Field investigations began at the Urbana campus shortly after the University was established. In 1876 corn was planted in a rotation experiment that was later named the Morrow Plots. Thus began the oldest continuously operating field experiment in the United States. As far as is known, no other plot in the world has grown corn every year for so long. The Morrow Plots were designated a National Historic Landmark in 1968.

Shortly after the Department of Agronomy was formed in 1899, its Head, Cyril G. Hopkins, began an unprecedented and far-reaching effort to establish soil experiment fields in many locations around the state. Dr. Hopkins died in 1919, but his efforts inspired others to continue the work thus begun. Of the 52 fields that were established, 34 were still in operation in 1924 (see map). In addition, the laboratory and field-plot work near the campus was expanding dramatically.

The "Soil Experiment Fields" were scattered widely, from Antioch to Unionville and from Carthage to Sidell. Not only did they provide for the acquisition of bench-mark data, they also made it possible for farmers all over the state to visit the fields and observe the effects of improved soil and crop management. It was intended that every farmer in the state have an experiment field within a day's drive of his home, and this intent persists today.

As more data were gathered and analyzed and as travel conditions and communications improved, some of the fields were phased out. With advances in technology and more sophisticated research techniques, larger and more complex field facilities became necessary. Thus in the 1930s, the Soil Experiment Fields system began to evolve into a system of fewer but larger Research Centers, each located so that the information



From 1867 to 1924, fifty-two research and demonstration facilities were established in Illinois. Currently, seventeen facilities totalling 8,400 acres are in operation.

Facility		Location (county)	Size (acres)	Established (year)
Experiment field with oldest continuous-corn plot in U.S.				
1	Morrow Plots	Champaign	1.25	1876
Multidisciplinary research and extension facilities				
2	South Farms	Champaign	2,047	1867
3	Dixon Springs Agricultural Center	Pope	5,100	1938
Research centers administered primarily through agronomy department				
4	Northern Illinois Agronomy Research Center (DeKalb)	DeKalb	160	1948
5	Northeastern Illinois Agronomy Research Center (Elwood)	Will	160	1960
6	Brownstown Agronomy Research Center	Fayette	150	1937
7	Orr Agricultural Research and Demonstration Center (Perry)	Pike	257	1979
8	Northwestern Illinois Agriculture Research and Demonstration Center (Monmouth)	Warren	160	1980
Small, old experiment fields run through agronomy department				
9	Dixon Soil Experiment Field	Lee	20	1910
10	Hartsburg Soil Experiment Field	Logan	20	1911
11	Toledo Soil Experiment Field	Cumberland	20	1913
Facilities operated by horticulture and medical center				
12	Pharmacognosy and Horticulture Field Station (Downers Grove)	DuPage	40	1952
Facilities operated by horticulture				
13	Illinois River Valley Sand Field (Kilbourne)	Mason	40	1969
Facilities operated by forestry				
14	Allerton Farms	Piatt	150	1947
15	Elizabethtown Field*	Hardin	33	1917
16	Oquawka Field*	Henderson	20	1915
17	West Salem Field*	Edwards	24	1912

* Established and operated for many years as an Agronomy Soil Experiment Field.

gained from it would be useful throughout a major soil association and agricultural production region.

Today, major field research facilities are located at seven sites around the state. Smaller specialized facilities are in use at other locations (see map).

The Experiment Station also uses research sites other than the established centers. For example, the Surface Mine Reclamation Project is being conducted on land in Fulton, Randolph, Perry, and Jefferson Counties. Over the years many cooperative research projects have been set up in particular problem areas as well. University researchers have worked with farmers or personnel from other agencies on land over which the University has had no direct control. These arrangements allow us to extend the scope of our research without the investment in land, development, and management required for University-owned facilities.

Some programs have a definite interstate and even international flavor. For example, our corn breeders use land on Molokai in Hawaii to provide another generation of progeny each year; marketing specialists keep track of commodities in ports around the world; and the International Soybean Program (INTSOY) sends researchers to Puerto Rico and coordinates a program with cooperators in about 100 countries. In addition, cooperative research projects in many different disciplines are under way with investigators from other institutions and agencies in the North Central Region and across the nation.

Experience has shown the value of having research facilities and locations that represent the range of environments in Illinois. Many investigations can and should be carried on in fields and laboratories on campus, where efficiency is heightened and costs minimized. But the Experiment Station has an undiminished need for facilities around the state to conduct research and to demonstrate improved agricultural practices to all interested citizens of Illinois.

Robert W. Howell, head, Department of Agronomy; Lester V. Boone, agronomist

Government — A Partner in Research

Laboratories do not always look like laboratories. At times, federal, state, and local government offices double as research facilities for agricultural scientists interested in public affairs. To get at valuable information, these scientists must know their way around Washington, D.C., Springfield, and dozens of courthouses and county offices throughout Illinois.

Research in public policy and public affairs explores the relationship of government to farms, agricultural production and marketing, and rural communities. Government agencies contribute to Agricultural Experiment Station research by providing funds, data, or counseling in research methods. And occasionally our specialists are called upon to testify at Congressional and legislative hearings to make recommendations based on their findings.

In Washington, D.C. The federal funds and grants authorized for research in agriculture, human resources, family studies, and rural development are provided under specific acts of Congress, such as the Hatch Act of 1887 and later legislation. The U.S. Department of Agriculture is responsible for administering these laws and allocating funds to the state agricultural experiment stations. Other agencies, such as the National Science Foundation, also provide research grants. As part of their work with the Experiment Station, scientists and administrators periodically travel to Washington, D.C., to be on hand when funding decisions are being made.

Federal offices are storehouses of valuable information. For example, data for research projects may be generated from statistics collected by the Statistical Reporting Service, the Economic Research Service, and other Department of Agriculture agencies. In research relating to international development, our scientists sometimes interact with the U.S. Agency for International Development in the Department of State.

From time to time we use international trade and census data collected by the Department of Commerce. Other useful data may originate with the Interstate Commerce Commission, Federal Trade Commission, Department of Labor, Environmental Protection Agency, or the General Accounting Office.

Senate and House committees publish the testimony of all witnesses who appear at public hearings in Washington, D.C. These Congressional hearings yield a mass of information that may be useful in research.

Also located in our nation's capital and in nearby suburbs are the offices of trade associations, farm organizations, and consumer and environmental groups, which collect data, present testimony, and conduct lobbying campaigns. Although the information must be ferreted out, often it provides us with research materials. Other sources of information are the proceedings of federal court cases, some of which deal with agricultural and environmental policy.

Federal offices serving regions, states, or counties can supply us with aerial maps used in soil conservation and price support programs. These maps have been helpful in measuring acreages, land use, and other geographic features in several projects.

In Springfield. Closer to home, Experiment Station scientists depend upon offices and organizations in the state capital for information and for help of staff members. For example, the Illinois Department of Agriculture in its regulatory activities collects data that scientists often find indispensable for research. The Department of Mines and Minerals, Land Reclamation Division, gathers information by counties on surface-mining permits, land use before and after mining, and the acreage affected. The Department of Revenue is a valuable repository for data on land sales, assessed valuation of property, and sales and income tax collections.

In County Courthouses. Almost every courthouse in Illinois keeps documents, files, and records that some scientist could use. An enterprising researcher can find data on taxes collected on farms and residential properties in the county collector's office; data on land transfers and sales in the county recorder's office; and records of estates, probate proceedings, and inheritance taxes in the office of the circuit clerk. Transcriptions from court cases involving land, landowners, taxes, and rural communities are also available for examination.

The quest for knowledge takes us into unlikely places. Government offices are no exception.

Harold D. Guither, professor of agricultural policy

The Champaign County courthouse and dozens like it throughout the state contain a valuable fund of information that researchers often draw upon to study public affairs.

Worldwide Connections

The sun is always shining on countries touched by the effects of Agricultural Experiment Station research and teaching. Yet here in the corn and soybean fields of the Midwest, many people may find it hard to imagine that activities of the Station circle the earth.

The international work of our scientists has become especially important with the increasing interdependence among the nations of the world. If we are to work together to solve mutual problems, we must become familiar with different heritages, cultures, values, and styles of behavior.

Through research, our scientists are able to focus upon specific problems and opportunities that are common to people in many geographic regions. Sometimes the gains are almost immediate, as when a shipment of corn produced in Illinois arrives in a foreign country. At other times a lag exists, for example between the research leading to development of a new process and the implementation of that process. Let me cite a few of the many other ways that the Experiment Station is involved internationally.

The most direct and obvious way is through our improved yields of corn, soybeans, and wheat, which add substantially to the total U.S. export of these commodities. In recent years about a fourth of all cash receipts from farming in the United States originated from exports of agricultural products. Approximately one-third of the corn and other coarse grains is exported. More than half of the soybeans and almost two-thirds of the wheat crop go abroad. Perhaps most remarkable is the fact that this food is produced by the 3 percent of the U.S. population engaged in farming.

A promising line of research is nitrogen fixation by maize. The result would be a more nitrogen-rich soil, thus enabling farmers to economize on the application of nitrogen fertilizer. Such an accomplishment would help developing countries, which in 1978 planted 60 percent of the world corn hectarage but produced only 30 percent of the world output. Also under study is single-pass production (or minimum tillage), in which seed would be treated with pesticides and fertilizers before planting.

In animal production, research is being conducted in the twinning of cattle in order to reap the economic advantages of multiple births. And in a cooperative venture with the People's Republic of China, Experiment Station scientists are looking into the possibility of breeding their swine with ours. Chinese breeds are highly prolific, while U.S. breeds have faster growth rates and leaner carcasses. People of both nations could benefit from this new breed.

International research is fostered by INTSOY (International Soybean Program). The largest international program in the College of Agriculture, INTSOY is working cooperatively with institutions in more than 100 countries, among them Sri Lanka, Thailand, Peru, Colombia, and Nigeria.

INTSOY helps farmers in less developed nations raise high protein soybeans for direct human use. The task is demanding, because growing soybeans in the tropics and subtropics requires the development of technologies suited to the climate and to the needs of small-scale farmers. New yet simple methods for storing and preparing the beans must also be developed and tested.

A small-scale farmer in Sri Lanka examines the plants in his soybean field.

Other agricultural development programs are in progress in Indonesia, Nepal, Spain, and the Eastern Caribbean. These activities are organized through the Midwest Universities Consortium for International Activities (MUCIA). The University of Illinois is one of seven Midwest member institutions of the consortium.

But it is not enough to conduct research and disseminate the results; the Experiment Station also plays an important part in educating the next generation of research personnel. This past year the Station supported more than 400 graduate research assistants, many of them from other countries. These apprentice scientists will soon be taking their places in universities and other research institutions throughout the world.

Especially in less developed countries, Station scientists work with others to establish new stations and systems that will support research activities. The best trained and most highly skilled scientists are ineffective if they stand alone without a worldwide institutional structure to provide facilities, general support, and the necessary communication among colleagues.

Our Station has been a leader in establishing and strengthening agricultural universities and institutions in India, Indonesia, and Sierra Leone. Most recently, Illinois scientists have been engaged in a project in Zambia to develop agricultural research and extension in that country.

Thanks to the work of the Experiment Station, the sun will continue to shine on green fields rather than on wastelands and poverty. A sufficient food supply to satisfy the global population is an important part of our dream for the tomorrows.

George K. Brinegar, director, International Programs and Studies

Scientists Behind the News

Shared Goals

Hundreds of research scientists are employed by the Illinois Agricultural Experiment Station. Although they come from many places and have a wide range of skills, one thing is clear from a major theme running through the essays in this section: Station scientists find it possible to work together harmoniously and productively. For every scientist named here as an example of a particular specialty, dozens of other scientists are conducting research on similar problems.

The extraordinary diversity of specialized talents is implicit in each essay. Specialties range from the biological and physical sciences through the social sciences and engineering. Coordination of so many disciplines stems first and foremost from shared goals and the direction of individual efforts toward them.

A basic goal is of course the production of high quality food (Fred Welch). Beyond this, there is some agreement — and room for disagreement as well — on what constitutes efficient production, distribution, and sharing in the benefits of production. Societal goals related to the sharing of benefits are discussed in the essay on the agricultural economy (Thomas Hieronymus).

Several subthemes also emerge. Marvin Steinberg, writing on food science, gives an example of how one generation of researchers influences the next. And in her essay on human resources and family studies, Marilyn Dunsing describes the step by step nature of research careers. Both statements are a reminder that science hinges on learning from the experience of others as well as on one's own past efforts.

A more pervasive subtheme is that coordination of effort is almost mandatory if complex problems are to be solved. Many research problems do not neatly fit the skills and experience of any one scientist, as Folke Dovring and others point out, but solutions can often be found through coordinated activity.

Lest these references to harmonious working relationships paint an idealized picture, let me also mention the difficult choices in applying scientific knowledge to the real world. Dovring describes some of the conflicting interests involved in the use of natural resources. Hieronymus, also, alludes to trade-offs in the working of the economy.

Science in the service of society is what the Agricultural Experiment Station is all about. This idea binds reseachers together. At the same time, any society includes competing interests, a situation that makes for debate and even controversy. Research scientists, like everyone else, must deal with controversy, along with sharing in the rewards of goal achievement.

Frederick C. Fliegel, professor of rural sociology

Geneticist Jack Harlan.

The Food Production Team

They came from Tennessee, Mississippi, Illinois, Texas, Utah, Indiana, Colorado, South Carolina, and many other states and nations. They are now scientists with the Illinois Agricultural Experiment Station. Although from diverse places, they are a lot alike and work toward a common goal.

They have inquisitive minds. They enjoy the excitement and adventure that come from discovery. They were motivated by the spirit of inquiry to prepare themselves intellectually through long years of formal education.

They were largely country kids who had been disciplined and tempered with farm chores assigned during their childhood. They have witnessed the breaking of dormancy in the plant kingdom with the advent of spring. They have seen crops wilt in the noonday sun, and then burst anew with vigorous growth when the rain showers came.

These scientists are familiar with history and the role that food has played in the wealth and power of nations through the ages. They recognize that food is good for barter anywhere in the world. They are aware that agricultural products exported by the United States are equal to one-half the value of petroleum imports.

Their common goal is the production of high quality food that is available at reasonable cost to consumers. They know that this country is rich in food and that Illinois is one of the leading agricultural states. And they know that none of this has happened by chance.

Food production begins with plant growth. Plants may be eaten directly by people or eaten by animals, which in turn provide food for us. Above all else, plants need nourishing soil in which to be anchored and grow. Illinois was blessed with fertile soils and a climate favorable for grain production. But with continued row cropping, our productive soil became less productive. Improving the soil environment and the plants themselves are some of the goals our scientists have for enhancing food production.

Plant growth and yield are the result of genetic and environmental factors. Genetic factors determine the yield potential of a plant, while the plant's environment determines how much of that potential is realized. The development of hybrid corn is a classic example of the way genetic research has been translated into increased food production. Better varieties of corn, soybeans, wheat, oats, and other crops frequently are made available to growers.

Evolving over thousands of years, our major crops have generated enormous diversity, although we use only a small fraction of that diversity in developing high yielding modern varieties and hybrids. The limited diversity has its drawbacks, however, because it makes a crop vulnerable to diseases and pests.

The strategy for genetic defense is to assemble as much diversity within each crop as possible so that resistances can be found when new forms of disease or new pests appear. Diversity is also needed to improve nutrition; widen adaptation; increase tolerance to cold, drought, saline soils, or other stresses; improve dependability; and increase yield.

In the past, the diversity of crop plants was collected by plant explorers sent to agricultural regions around

the world. Today, with new but less diverse high yielding strains, concern for the disappearance of invaluable genetic resources has sent geneticists like Jack Harlan scurrying to study crop diversity and collect samples in more than 50 countries.

The work may sound like a paid vacation, but he often runs into problems: dysentery, bed bugs, mosquitoes, fire ants, farmers who chase him out of their fields at the end of a rifle, and especially transportation. Harlan has collected on horseback and from dugout canoes, from oxcarts, horse carts, bicycles, and on foot. He has been to remote villages and exotic places that tourists never see. The work is not always easy.

After the plant geneticists have produced seed with good yield potential, other scientists from the Experiment Station and Cooperative Extension set about creating a favorable environment in which the seed may grow. The roll call of researchers, along with their projects, is impressive:

- Cultural practices to help plants make better use of the sunlight — Doyle Peters, Bruce Vasilas, Robert Pope, John Siemens
- Better relationships between water and plants — Marlowe Thorne, Carroll Drablos, Walter Lembke
- Improved chemical tests to measure the ability of soils to supply essential elements — Touby Kurtz, Ted Peck
- Rate, time, and methods of fertilizer applications — Robert Hoeft, Fred Welch
- Weed control — Fred Slife, Loyd Wax, Ellery Knake, Marshal McGlamery
- Disease control — Wayne Pedersen, Donald White, Barry Jacobsen, Malcolm Shurtleff
- Insect control — Steve Moore, Donald Kuhlman, Kevin Steffey

I have presented only one segment of research aimed at increasing the quality and quantity of food and only a handful of researchers. The crops still must be harvested, transported, stored, processed, and marketed. Many Experiment Station scientists, unnamed here, are making important contributions in these areas through their research.

L. Fred Welch, professor of agronomy

Entomologist Kevin Steffey.

Plant physiologist Loyd Wax.

Cooperation Among Food Engineers

Food engineer Marvin Steinberg.

Many of us have an idol, a person whom we seek to emulate. One of my idols was H. Orin Halvorson (1897-1975), a man whose major research achievements were as interdisciplinary as his training. First a chemical engineer and then a microbiologist, Halvorson pioneered many projects, among them studies in the physiology of bacterial spores. In his research on the heat tolerance of spores, he combined his knowledge of mathematics and heat transfer and applied these results to develop specifications for the sterilization of foods by canning, a classic contribution both to science and to society.

Following Halvorson's lead, I too went from chemical engineering to microbiology, and from there to food engineering. This interdisciplinary odyssey started while I was working on an M.S. degree in chemical engineering at the University of Minnesota. During the year that I took biochemistry, I held a part-time job in the food industry. When a yeast-spoilage problem caused a large financial loss to the company, I decided to study microbiology as well.

My first bacteriology class was taught by Halvorson, whose engineering background, keen intellect, and warm humanity inspired me greatly. Later on he accepted me as one of his graduate students. Just at the time I had finished the course work for the Ph.D., he was invited to become head of the Department of Microbiology at the University of Illinois, so I came here also. I completed my graduate work in the Department of Food Science under Z. J. Ordal, who had won his Ph.D. under Halvorson. While writing my dissertation on food fermentation, I was offered a position to teach food engineering and have remained in the department to the present.

Food engineering is a specialized form of bioengineering, which melds the chemical and biological sciences with the engineering sciences. Fermentation engineering is my earliest and again most recent research interest. It rests on microbiology and chemistry, and on heat and mass transfer from chemical engineering.

The study of food processing is indeed a complicated affair. As the problems approached by scientists become more complex, an interdisciplinary attack will become more vital rather than less so. One scientist cannot be expert in all the areas needed. Therefore, interdisciplinary problem solving requires interactive cooperation. Let's see how two of my research programs have followed this approach.

The *Wall Street Journal* of October 3, 1980, carried a news story headlined "Food Industry Seeks Savings in Pouches." The article went on to say that food sterilized in flexible containers called pouches lasts as long on the shelf as do canned goods in the traditional tin can. The pouches are made from laminated sheets of aluminum foil and plastic films. One advantage quoted in the article is the saving in energy. Processing beef stew in a pouch, for example, requires 60 percent less energy than preparing the product in a can. Another advantage is that pouches take 40 percent less time to sterilize, so the food looks and tastes better. The list of advantages goes on.

The retort-pouch concept was originated by Alvin I. Nelson, professor of food processing at the University of Illinois. He graciously invited me to help him prove his theory when I first came to work with him in 1951. This work started a close collaboration that spanned more than a quarter of a century until Nelson's retirement in 1978.

Another example of interdisciplinary research is the study of semimoist foods. Foods processed this way contain enough water to look and feel moist, not dry, but not enough water to allow bacterial spoilage at room temperature. Such foods are less energy intensive, less expensive, and more convenient to process than foods prepared by the traditional methods of canning, freezing (or refrigeration), and drying.

My research on semimoist foods has been done in collaboration with Nelson and L. S. Wei, professor of food science. It has concentrated on the basic properties of water and its relations to other food constituents. This work has led me into a love-hate affair with nuclear magnetic resonance, an instrumentation method that is helping us gain valuable insight into these relations.

Chemistry, microbiology, mathematics, engineering — these are but a few of the many disciplines needed to put safe, wholesome, and economical foods into the hands of consumers. Through my many years of experience, interdisciplinary teamwork has become the basis of my research philosophy.

Marvin P. Steinberg, professor of food engineering

People Studying People

The quality of life and ways to improve it are at the core of research conducted in the School of Human Resources and Family Studies. Our projects focus primarily on individuals and their relationships with other people and with technology in the settings most critical for human development: family, home, and community.

A unit within the College of Agriculture, the School concentrates its research efforts in several major areas: family and consumer economics, foods and nutrition, human development and family ecology, and textiles and interior design.

The School has four departments and 28 researchers, many of whom have had a long-standing interest in their current projects. If space allowed, I would like to introduce all of these men and women to the reader, to show the breadth of their work, the talent and enthusiasm they bring to it, and the direction they are going. Instead, let me present profiles of two associate professors whose work typifies our research goals.

Sonya Salamon is an anthropologist studying customs, physical and cultural characteristics of people, and especially their social relationships. Before joining our faculty in 1975, she carried out field research with middle-class, urban families in Japan and West Germany. Since then, although still focusing her research on families, she has changed the emphasis somewhat as a result of working in a land-grant environment. She is now studying Illinois farm families who live in communities in the same county, settled at about the same time, growing the same crops in similar soil, but with different ethnic backgrounds.

Salamon's goal has been to discover the extent to which ethnic values influence family-land relationships and the inheritance of land among Irish and German farm families after a century of settlement. The findings from this study encouraged her to investigate other communities.

Currently she is completing a study of Swedish and Yankee families living in an adjoining county, but having the same soils and crops.[1] (Yankee families are descended from settlers who moved from the East Coast to the Midwest as the frontier shifted.) Her future plans include additional studies of German, Irish, and Yankee communities to determine how equitable land transfers have been from one generation to the next in nuclear families.

Mary Frances Picciano is a nutritionist concerned with optimizing the nutrition of infants. As a graduate student working in a laboratory where trace elements were studied, she became particularly interested in these elements in infants. During that time she also turned her attention to the composition of human milk.

Her concern sprang from the realization that in our country infant mortality and morbidity statistics are alarmingly high and that infancy is the only period in the life cycle when a "sole" food is adequate as a total source of nutrition.

When she began her research, there was almost no knowledge, derived from modern analytic techniques, on how maternal nutrition influences human milk consumption and, in turn, the nutrition of infants. Picciano decided to concentrate her research efforts in this direction. Her interest in trace elements led to her studies of iron and the iron status of breast-fed compared with formula-fed infants.

Findings from these studies suggested that factors other than total dietary iron are responsible for iron inadequacy in breast-fed infants; folic acid was implicated. Picciano is currently conducting a study to assess folic acid status of breast-fed and formula-fed infants in light of dietary iron intake.

Varied as the School's research projects are, they reflect the developing interests of our scientists over many years. But whatever the project, the well-being of individuals and families will continue to guide us in our plans for the future.

Marilyn M. Dunsing, director, School of Human Resources and Family Studies

PHOTO BY DEAN J MEADOR

Sarah Barrett, 10 months, and countless other children will have a healthy start in life with the help of researchers who are studying infant nutrition.

Farm families, rural communities, and land inheritance are among the research interests of an Experiment Station anthropologist.

Resource Development — A Problem for Many Minds

Cooperation among scholars — that's the key that is opening research doors throughout the Agricultural Experiment Station. Long before there was any sense of urgency, people in the Station began working together to improve the natural resources available for Illinois agriculture.

Agronomists, horticulturists, soil chemists, and animal scientists, to name only a few, have actually expanded the resource base by their innovations in applied technology. In this article I would like to introduce briefly some of the people who work to protect and develop the resources of this state.

Basic to this continuing effort is the mapping of Illinois soils, perhaps our most vital resource. This work has been done under the leadership of Joe Fehrenbacher. Over the years he and his colleagues have gradually replaced older soil maps with more advanced ones. At present, book-length monographs with detailed maps are on hand for about 40 counties.

Now that land is being used more intensively than ever before in our history, Station scientists are expanding their study of land and water. Agronomists, led by Robert Pope, are studying soil erosion, while economists, among them Earl Swanson and Wesley Seitz, have found that landowners see little incentive for incurring conservation costs, which may not pay off in their lifetime. Swanson has conducted research on irrigation, as yet a minor issue in Illinois agriculture. He is also active in research on intensive application of fertilizers and pesticides, working cooperatively with other specialists, such as agronomist Fred Welch and agricultural entomologist Luis Zavaleta.

The loss of farmland to other uses has received considerable coverage in the press during the past year. The problem is nothing new to Experiment Station researchers. Nor is the special issue of lands being strip mined for coal. Reclamation of these lands is the subject of a major nationwide inquiry led by Seitz. David Chicoine and John Quinn, also agricultural economists, have conducted intensive studies on the same issue in selected areas in Illinois.

Energy problems have captured the attention of many of our scientists. Agriculture as a producer of energy is a new research area strongly supported by Experiment Station Director Raymond Cragle. Three possible

Soil, the state's most important natural resource, must be protected and developed.

PHOTO COURTESY OF MIKE SPONSLER

Restoring the land to its original productivity after strip mining requires replacing topsoil on a high quality root zone.

feedstocks — raw materials from which energy can be created — are grain crops, forage crops, and wood from existing woodlots or specially grown tree plantings.

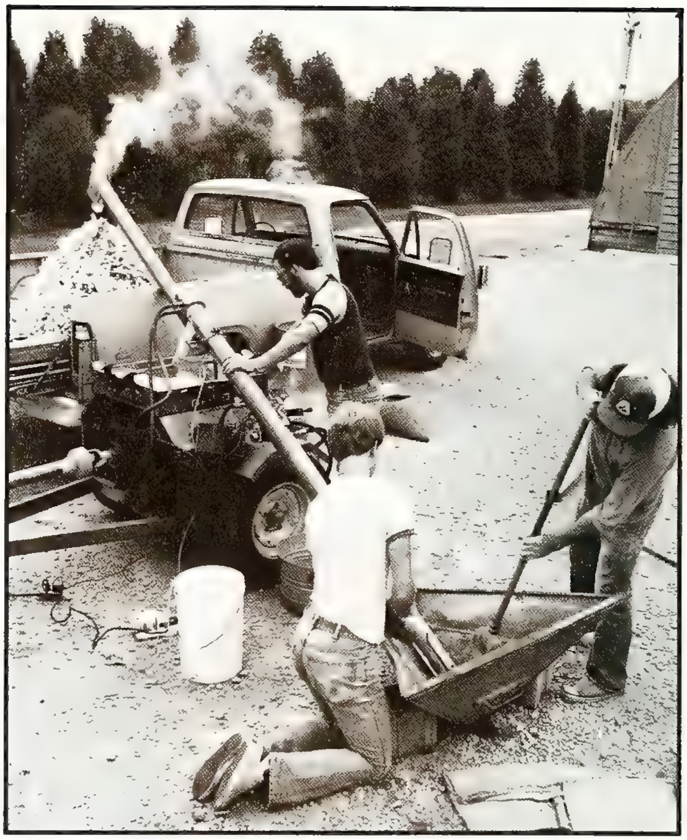
This latter source is being investigated in the Department of Forestry by Timothy White, Gary Rolfe, and others. Rolfe, along with Poo Chow, is also exploring ways of using woody biomass for energy. The land base for biomass production is receiving the attention of Folke Dovring in cooperation with Robert Herendeen of the Energy Research Group.

Alcohol energy systems for farms, as well as other alternative farm fuels, is the subject of intensive research conducted by agricultural engineers Errol Rodda, Donnell Hunt, and Carroll Goering. Dovring and Herendeen are investigating the working of alcohol distilleries. John Braden in agricultural economics is examining likely repercussions on farm size and other farm conditions, while Welch is studying the consequences for soil conservation if crop residue is removed for energy use.

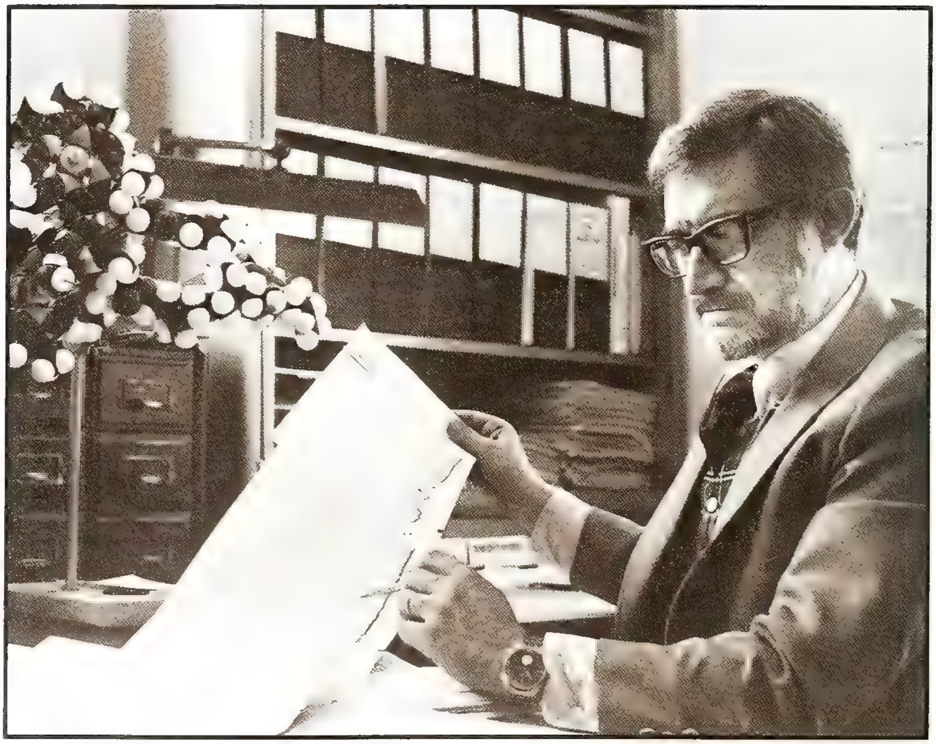
If successful, energy production from biomass could have far-reaching consequences by rendering energy more benign to the environment and by increasing competition for the use of land. But competition for land could actually decrease if success eventually crowns the efforts of Constantin Rebeiz, a plant physiologist in the Department of Horticulture. His goal is to create "cell-free agriculture" through the synthesis of carbohydrates with the aid of synthetic chlorophylls.

However, none of these projects looks directly at the question of whether there will be scarcity or plenty in our food supply. Ultimately, consumption habits, especially in the United States, will provide the answer. Lun Shin Wei and colleagues in the Department of Food Science are now conducting research on food processing, and in particular on the production of high protein foods from crop materials. From this research may very well come the flexibility we need to redirect our consumption habits in the future.

Folke Dovring, professor of land economics



Agricultural engineer Thomas Brumm (near truck) and assistants use extruder to prepare corn for alcohol production.



Constantin Rebeiz's research on synthetic chlorophylls and cell-free agriculture may reduce the competition for land some day.

Economists in a World of Uncertainty

The economic system that furnishes most of the food and fiber for the United States and large amounts for consumers in many other countries is the most productive and efficient in the world. Throughout the history of the United States the productivity and efficiency of this system have increased dramatically and now stand at a peak. Long-range trends say that the peak is transitory, with further gains lying ahead.

Technological gains have taken place within an economic system that has fostered and stimulated growth. Behind the system are the people who operate it and, through their decisions, direct the changes that take place. Among those involved in major decisions are the research economists.

For economists, their laboratory is the world around them, a world controlled by people who order events and establish the level of productivity. Researchers observe the way that activities are performed and organized. They measure, evaluate, and search for methods to improve the processes. They recommend and sometimes gain the reward of seeing their recommendations accepted.

Economists live in a world of uncertainty because of the unpredictable behavior of people and because of the trade-offs between inputs and outputs, short run and long run, and individual and general welfare. Our goals are often in conflict because of the concern for individual success and for the productivity of the system.

To help sort out some of the confusion, here is a picture of what a well functioning economy should do. It should:

- Enable people in many occupations to be productive enough to earn a living and to become more productive so that their standard of living rises. The focus is on earning money. The system must be organized to provide people the opportunity of exploiting their talents.
- Orient production and marketing in directions that consumers desire. The purpose of production is consumption and consumer welfare.
- Maximize the efficient use of resources through a two-part program of reducing cost and increasing output.
- Maximize long-run productivity and welfare by preserving resources and improving the environment. The short-run goal of maximum productivity and the long-run goal of resource preservation and environmental improvement must be in harmony.
- Distribute the fruits of production and wealth in a way that meets the social goal of individual welfare.

The pricing system is one of several areas in which economists conduct research to help achieve the ideal. The United States has a competitive agricultural economy, the key to which is its pricing system. Prices and expected prices order and direct the use of resources, as well as the output, processing, and distribution of products. The future is uncertain; therefore, economic ventures are speculative because their success or failure is unknown in advance. Researchers work toward making pricing systems sensitive to various forces so that processes are as efficient as possible. Developing methods of foreseeing the future is another goal related to pricing.

Farm businesses and their organization, management, and financing are an important item on the research agenda of agricultural economists. Their purpose in this area is to devise better combinations of land, labor, machinery, and money to help improve the productivity and income of farm operators.

The marketing processes from farm to final consumer are vast, requiring more inputs than does the production of raw agricultural products. Much research is done on this whole intricate system, which covers transportation, processing, quality measurement and control, wholesaling, and retail distribution. Central to these processes is the pricing system: as it becomes more efficient and productive, returns to producers increase and consumer satisfaction rises.

Land, a key agricultural resource, is a major subject of research. The short-run and the long-run use of land has social implications, along with the ownership, control, and transfer of land and its share of the returns to production. The use of inputs such as fertilizers and pesticides, as well as the disposal of wastes, are related matters of public concern. Researchers delve into costs and returns as they affect productivity, individual equity, and the general welfare.

Finally, the many important roles that government plays in agriculture are scrutinized by researchers. Governmental decisions enter into land use, environmental quality, taxation, marketing processes, exports, price and income supports, and consumer protection. In all of these decisions, people make trade-offs between productivity and equity and — again — between the short run and the long run. As economists, we have the responsibility of weighing these trade-offs in search of optimum solutions.

Thomas A. Hieronymus, professor emeritus of agricultural economics

In Progress

Research — The Basis of Progress

"In Progress" will appear regularly in future issues of Illinois Research. *The column will feature brief reports of ongoing research activities. To introduce the column, Robert Goodman presents some reflections on the nature of research and its place in agriculture.*

Research is a critical natural resource, as critical as the soil and water needed to grow food. A work of art as well as a discipline, the best research is a product of the curiosity and creativity of dedicated men and women who are free to explore, to experiment, to challenge, and to think. Research is also a highly complex activity, but it is easily taken for granted when the process is working well.

Few things are as basic to life or as important for good health as the food we eat. But without the knowledge derived from the agricultural research of the past, we would be unable to meet this basic need today. Three types of research come into focus when we think about how soon the research product — knowledge — might be used: in a year or two, five to ten years from now, or perhaps not for another generation.

With the first type of Experiment Station research mentioned, needs and available knowledge are clearly related. The task is to adapt the knowledge to the problem. A good example is the identification of a new insect pest and methods for controlling it. The development of improved feeding regimens for livestock is another example. Results of this work can usually be applied in the field more or less immediately.

With the second type, the payoff may be five to ten years away. Some problems, although well identified and urgent, are simply too complex for quick answers. Such research often requires the cooperative efforts of scientists in several disciplines. Falling into this category is the development of soybean varieties adapted to northern and central Illinois and resistant to the soybean cyst nematode. Other examples come to mind, such as new tillage practices to control soil erosion, the effects of changes in international and domestic energy costs on agricultural productivity and profitability, integrated approaches to the control of plant and livestock diseases, and the processing of soybeans for direct human use.

Finally, in the third type of research, underlying principles and processes are discovered. The immediate product is new knowledge about how things work. Occasionally, we even arrive at revolutionary insights into better ways of doing things. Advances in agriculture for the next generation will be based on the results of this research.

Unfortunately, the work is often hard to describe in relation to popular issues of the day. Frequently misunderstood, these projects are sometimes the easiest to put off until economic conditions improve. This can be dangerous, because the results will undoubtedly help to determine the health and economic well-being of future generations. Perhaps the best way to appreciate how vital these projects are for the future is to step back and look at current applications of similar work done in the past.

One of the most important advances of 20th century science was the discovery of the antibiotics produced by streptomycetes. The public usually associates antibiotics with human medicine, so some readers may be surprised to learn that a soil microbiologist, working in another agricultural experiment station, made the original discovery. Scientists in our own Station played a major role in discovering several of the early antibiotics still used today and in describing how they combat infection. Although used in human medicine,

antibiotics have many important agricultural applications as well, for example in veterinary medicine and in tissue culture.

The impressive corn yields on which the present-day economy of Illinois depends can be traced directly to what began as fundamental research in plant genetics at the end of the 19th century. In more recent years, Station scientists were able to provide a swift solution to the urgent problem of southern corn leaf blight, but only because the basic work had been done several decades before.

Pioneering research, worthy of the traditions established by previous generations of scientists in the Illinois Agricultural Experiment Station, is continuing in the laboratories and field plots at Urbana-Champaign and elsewhere in the state. Taking their place alongside of more traditional subjects are entirely new studies in the workings of the immune system, the molecular basis of disease in plants and animals, the nature of the gene, and genetic engineering. There are also new approaches to studies in reproductive physiology, human nutrition, and photosynthesis, among others. It may be many years before the results of some of these studies will be used. Such work is not a luxury, however. It will be the cornerstone of future progress.

Robert M. Goodman, professor of plant pathology and international agriculture

With a menagerie of hibernating bears, Ralph Nelson is studying the clinical similarities between several human disorders and a bear's normal winter sleep.

PHOTO BY DALE WITTNER

A winter's tale

The winter sleep of bears is a metabolic feat that has captured the interest of University of Illinois nutritional scientists. In hopes of discovering new ways to treat humans for sleep disorders, kidney failure, obesity, and starvation, researchers are looking for a hormone that may be responsible for controlling the hibernation pattern of bears.

Ralph Nelson, professor of clinical sciences, began these studies eleven years ago at the Mayo Clinic in Minnesota. Results have already led to the use of a low-protein, low-fluid diet for patients with kidney failure. On this diet, people without kidneys are able to go ten days instead of the typical three before needing treatment with an artificial kidney machine.

The month before their winter sleep, bears eat enough to gain more than 100 pounds. They can then sleep for as long as five months, burning 4,000 kilocalories a day without eating, drinking, urinating, or defecating. Hibernating bears maintain near-normal body temperature and can awaken if disturbed.

According to Nelson, a bear's reaction to hibernation resembles a human's response to starvation: body fat is burned up. But while starving humans lose protein as muscles deteriorate, a bear's lean body mass remains essentially unchanged. Combustion of fat must therefore supply the energy for hibernation metabolism.

Under the influence of a muscle-relaxing drug, the first bear used in this research arrived at the Mayo Clinic on the back seat of a Volkswagen. Nelson hopes to move his animals to Illinois once arrangements can be made for permanent facilities.

Anorexia and vitamin A

Many overweight people can't stop eating, but victims of anorexia nervosa can't stop dieting. Although the anorexic, usually a woman, deliberately starts dieting to lose weight, she is unable to stop for psychological reasons. Physiological problems develop when she begins wasting away. A distorted body image is part of the picture: victims of anorexia think they are fat, when in fact they are emaciated.

Food scientist John Erdman is contributing to studies of the disease with his research on vitamin A and stress. He and his research team are running blood tests on patients at the anorexia nervosa treatment center at Carle Clinic in Urbana to determine the changes in vitamin A metabolism.

He has found that one unusual symptom of the disease is the elevated blood carotenoids, which are precursors of vitamin A. Carotenoids are the yellow and red pigments in carrots, sweet potatoes, milk fat, egg yolks, and green leaves. Elevated levels indicate a failure to form vitamin A from that particular compound. Severe weight loss from other diseases such as cancer do not result in the high blood carotenoids.

One type of tripsacoid maize grows tall enough to dwarf Jack Harlan, who has been studying the strange new genetic material.

Typical tripsacoid ears.

Bizarre breed of corn

Disturbance in gene regulation is how Jack Harlan, professor of agronomy, accounts for the bizarre results obtained from a cross between corn and the native Illinois grass Tripsacum. This new genetic material may provide useful traits for corn breeding.

Tripsacoid maize, as it is called, resembles wild maize in certain respects. Some of the ear branches are more than 6½ feet long and have as many as sixteen ears per branch. Although many of the ears do not produce grain, the potential is there.

"This is very strange corn," Harlan said. "I can't put my finger on any genes that we can be sure came from Tripsacum. There probably hasn't been much gene exchange, but the gene control has been disturbed." Harlan believes that his research may help explain some things about hybrid vigor and evolution above the species level.

Women essential to farming

In Illinois, men are considered the farmers, but today the farmer's wife often makes a substantial contribution to the operation. Compared with urban families, everyone in the farm family is expected to pitch in and help run the business. Their contribution gives family members a sense that their work is beneficial to the farm as a whole, notes Sonya Salamon, associate professor of family relationships.

Farm wives realize they are essential to the farm operation, and their husbands give them credit for their help. Women's liberation has therefore never been a big issue for these women. An estimate based on reported labor time shows that women on family farms average 19.9 hours of farm work per week, compared with 41 hours for men. This figure does not include housework.

As families become smaller and children remain in school longer, the role of the farm wife has become increasingly important to daily farm work. Now that she no longer has to feed large threshing crews, the wife has more time to spend working on the farm. Modern technology has also increased a woman's role in the field, because operating a tractor doesn't require much strength.

The culprit in horseradish disease

Illinois, producer of more than half of the nation's horseradish, has been plagued for some forty years with brittleroot disease. In 1979 it claimed 60 percent of the state's crop.

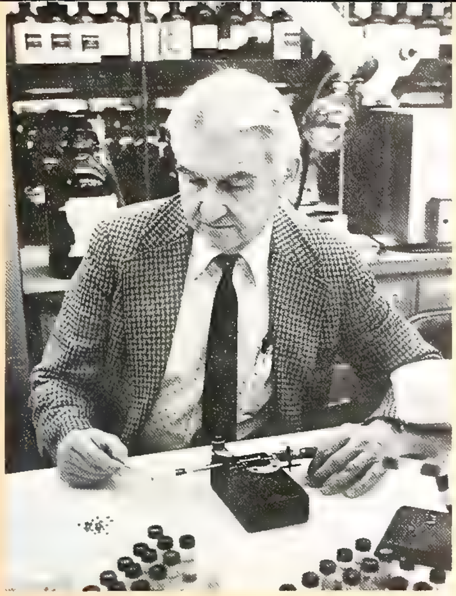
Agricultural scientists at the University of Illinois and the Natural History Survey recently identified the organism causing the disease and an insect that spreads it — the first steps in developing controls.

The organism is a rudimentary bacterium called spiroplasma, which also causes an important citrus disease in southern California, according to plant pathologist Robert Goodman.

It's not clear how the organism gets to Illinois; its occurrence has never been confirmed east of Arizona. Goodman says the pathogen could be living on other plants in the area or it could be blown in by high winds.

The beet leafhopper was used experimentally to transmit the spiroplasma in the greenhouse, but the researchers do not know which species of leafhopper is responsible for spreading the disease in Illinois.

Entomologist Jerry Schultz and plant pathologist Jacque Fletcher are part of a team that has recently identified the organism causing brittleroot disease.



Wild squash laced with insecticide is a new — and lethal — diet that Robert Metcalf is developing for corn rootworms.

Unusual bait for corn rootworms

Corn rootworms have a craving for cucurbitacin, a bitter substance that's lethal to other insects and animals. Present in a variety of wild squashes, cucurbitacin is 1,000 times more bitter than strychnine, according to entomologist Robert Metcalf. "These beetles can eat 2,000 times the amount lethal to laboratory animals. They thrive on it. Its presence makes them stop everything, eating corn included. The males even ignore the female sex pheromone."

Last year, corn rootworms cost American farmers about $1 billion in crop damage and insecticides. Using the bitter squashes to trap the beetles could cut the amount of insecticides normally required by 10 to 100 times, Metcalf said. Some of the most destructive insects in the United States feed compulsively on cucurbitacin. This group of insects includes northern, southern, and western corn rootworm beetles, the striped cucumber beetle, and the banded cucumber beetle.

Metcalf said it may be possible to combine ground up squash and small amounts of insecticide for broadcasting over corn fields to bait the beetles. Manufacturers of corn insecticides are interested in finding out if the bitter substance can be combined with soil insecticides to kill larvae in the soil, a possibility that Metcalf hopes to look into eventually.

Complex pathway in chlorophyll synthesis

Following their discovery of new chlorophylls in 1979, Constantin Rebeiz and colleagues have concluded that the way these chlorophylls are made in nature is far more complex than once believed.

Like other biological processes, chlorophyll biosynthesis proceeds through a set of biochemical reactions known as a metabolic pathway. Rebeiz, professor of plant physiology, has found that descriptions of the old pathway were an oversimplification and may be in error. He has proposed a new multibranched pathway, which involves about ten new compounds (metabolic pools) previously unknown.

Rebeiz's research brings closer the possibility of developing man-made photosynthetic membranes that may be more efficient than plants in converting solar energy, water, and carbon dioxide into food.

Ethanol from fast-growing trees

That "tiger in your tank" may be replaced someday by an autumn olive, a sycamore, or a black locust. University of Illinois researchers studying fast-growing trees have found that these species are the best for conversion into fuel alcohol.

Plantation production, although not economically feasible now, may eventually provide an alternative to row-crop production, particularly on marginal lands, according to Gary Rolfe, head of the Department of Forestry. About 750,000 acres of land in Illinois are marginal for agricultural purposes.

Biomass materials can be processed to produce ethanol, which is used alone as a fuel or mixed with unleaded gasoline to produce gasohol. These materials can also be used to fire boilers or can be mixed with coal to stretch supplies.

Enzymes: natural meat tenderizers

University of Illinois researchers are trying to increase the tenderness of beef at a price that is easy on the grocery budget. "Butchers have known for years that by hanging up a piece of muscle for days, it will become more tender," said animal scientist Peter Bechtel. "We wondered if this is caused by the enzymes in the muscle itself."

Bechtel's research shows that enzymes, known to break down major muscle protein in live animals, are also active after slaughter. He is looking for a way to put these enzymes to use to tenderize meat, perhaps by finding a method for getting them to work faster.

Proteins in all animals are constantly turning over through synthesizing and degrading mechanisms. The enzymes involved in the turnover rate are the ones Bechtel found to be still active after an animal has been slaughtered.

It has been known that the turnover rate is important in live animals. In a related aspect of his research, Bechtel said it may be possible to increase the efficiency of making muscles by altering the expression of the enzymes in live animals. This process would involve altering the rate of protein degradation while maintaining the rate of protein synthesis.

New use for dairy wastes

Dairy cattle waste, found to be similar in chemical composition to Bermuda grass hay, may soon be used as a source of roughage for ruminant animals. Sheep can digest certain types of plant fiber present in solid dairy waste when the fiber is incorporated into rations, said animal scientist George Fahey.

Fahey's research team is using chemical treatments on the ensiled material to improve nutritive value of the waste fiber. This process will aid the release of energy trapped in the fibrous mixtures. Farmers use the liquid from dairy waste as a fertilizer. At present, however, the solids are essentially worthless and the land can become overloaded with them.

Serving the Public

Private Citizens

The Agricultural Experiment Station works for all citizens of Illinois and takes seriously its mission to serve them. This statement may surprise many people who think that the Station works only for farmers and those in agribusiness. The Station's research does indeed deal with many aspects of the agricultural industry, but it also includes projects dealing with improvement of home and community life as well as the welfare of consumers.

Our investigations reach out and touch the lives of all citizens in every walk of life in all parts of the state. As a result, Illinois citizens benefit in some way from the work of the Station, whether they are part of the agricultural production process, employees of the food and fiber industries, members of families and households, or participants in government or other social institutions. Though oftentimes hidden from public view by the complexities of technical projects, the ultimate goal of Station research is improvement of the health and well-being of people.

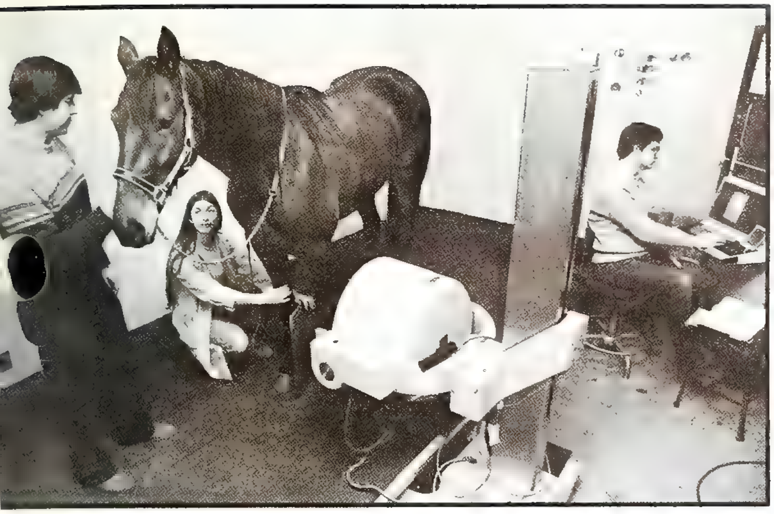
From the panoramic view of Experiment Station activities, concerns, and personnel presented in this issue of *Illinois Research,* it is fairly obvious how the Station serves the people of Illinois. Some further examples may help clarify its contributions, however.

One of the fascinating aspects of research in agricultural production and marketing is that producers and consumers both benefit from new technology. For example, improvements in plant and animal genetics lead to greater profitability for farmers, but also ensure an adequate supply of wholesome food for consumers. The same can be said for research in fruits and vegetables, but with added direct benefits to nonfarm households with gardens and orchards for home use. Research in pest management benefits producers and consumers alike while helping to protect the environment against potential hazards. Studies in the veterinary and animal sciences lead to better health for farm animals, for pets, and even for zoo and circus animals, which people throughout the state enjoy.

Research in nutrition has a direct bearing on human as well as animal health. Little known, perhaps, is that the results of nutrition research are applied to school lunch programs and diets in hospitals and other health-care institutions. The special dietary needs of infants, pregnant and lactating mothers, teenagers, and the elderly are also part of our program. Research in the food sciences benefits not only the food processing and distributing industry, but also brings to the consumer fresh, safe, and tasty products.

Station programs take into account that families are under stress from every quarter today. Researchers in child development and family studies are concerned about the physical and social development of family members and their ability to manage resources wisely in a complex society. Other researchers are examining the ability of farm families to transfer property to the next generation without literally destroying the production unit. The results of these investigations will be of long-range importance to farmers and to the community as a whole.

Productive agricultural land in Illinois is being pressed into nonagricultural uses such as urban and industrial expansion. Studies on land use and the development of tools to protect agricultural land contribute to the welfare of agriculture, but also help ensure the consumer of adequate agricultural resources for the future.



Pet owners and livestock producers depend on research to keep their animals healthy.

Research ensures urban consumers of safe, wholesome food at a reasonable cost.

Likewise, research on water quality and the control of soil erosion is helping to conserve and develop the natural resources upon which we all depend.

Research on public policies affecting food and agriculture is of great importance to all citizens, because these policies influence both the income farmers receive and the prices consumers pay. Recent studies on the tax structure in Illinois, especially farmland taxes, have long-term implications for farmers and for local governments and their ability to provide community services and facilities.

The catalogue of research projects is truly impressive. Studies of small farms, rural transportation, population change and migration, energy conservation and agricultural energy sources, application of urban sludge on farmland, and forest utilization are but a few examples of the broad range of investigations that benefit Illinois citizens directly or indirectly.

The Experiment Station actively seeks out real concerns and real problems. It does so through departmental and College advisory committees, and through contacts with numerous state and federal agencies and commodity and consumer groups. Through peers and professional organizations, our researchers are continuously in touch with developments and problems that affect the lives of those whom the Station serves.

Harvey J. Schweitzer, assistant director, Agricultural Experiment Station

Agricultural engineer Donald Jedele gives homeowners some money-saving tips on how to conserve energy when building new homes or winterizing older ones

Public Agencies

In response to the demands of voters and taxpayers, our elected officials at the local, state, and federal levels of government have initiated an array of public programs. A large, active, government sector has become characteristic of modern society. Even now, while public programs and the taxes supporting them are the focus of public evaluation and political debate, demand for many of these programs has not lessened. For example, concern for soil erosion, water quality, nutrition, and food safety is not likely to dissipate during budget deliberations.

Public agencies, which are the suppliers of services, are charged with carrying out the operations of government. The policies and programs of these agencies are designed to achieve goals that are democratically established. As users of information, many agencies are served by the Illinois Agricultural Experiment Station. Through applied research the Station provides information on the use of existing technologies, and through basic research develops new technologies and ways of understanding problems and issues. This information helps agencies to serve the public efficiently and allows them to go beyond contemporary thinking as well.

When interacting with public agencies, the Station can assume several roles: it can adapt its research to existing public goals, be neutral or noncommittal towards them, or critical of them. These four roles lie along a continuum, with the adapting role at one extreme and the neutral role at the other.

Regulatory bodies such as the Illinois Environmental Protection Agency often look to the Experiment Station for assistance in evaluating their programs.

Adapting to existing public goals. The central idea behind this role is that the Station is a source of skills, expertise, and knowledge that agencies can draw upon to help achieve goals that have already been determined. Agencies look to the Station for information to help them reach their current goals. Station scientists, for example, interacted with the Illinois Department of Agriculture when it was forming procedures for monitoring the compliance of coal companies with standards of surface-mining reclamation.

Neutral towards existing public goals. In contrast to the adapting role, research conducted in the neutral role is detached from any existing goals or programs of a public agency. Many basic research activities fall into this category. Tangible application of the results is not always immediately obvious, but the fundamental thinking provides an inventory of information that agencies may eventually apply. Studies of population redistribution are examples of this type of activity. The Illinois Bureau of the Budget, for instance, might refer to such information when projecting state revenues and expenditures.

Noncommittal towards existing public goals. In this role Station scientists are aware of an agency's goals, but are searching for the most desirable policy or program. Sets of alternatives and expected outcomes are compared. This role allows room for examining controversial issues without taking sides. Public goals are furthered by understanding the issues and clarifying the alternatives. Unfortunately, with no firm conclusions, the findings may be ignored. With information on alternatives, the Illinois Environmental Protection Agency, for example, might be aided in evaluating its rules and regulations.

Critical of existing public goals. Evaluative research that critiques existing goals aids in the review of public policies and programs. While the critical role may not always be welcomed, it often stimulates needed redirection. In this role, scientists identified and evaluated inequities in the 1979 formula-based farmland assessment law and suggested alternatives to the Illinois Department of Revenue.

Public agencies are important clients of the Experiment Station, and we have several ways of working with them. Recently, with increased concern for accountability in a short time frame, there has been more emphasis on the adapting role and less on the neutral and critical roles. This situation is particularly true with tight budgets and increased reliance on funding from short-term grants. If carried to an extreme, the shift in emphasis could mean the loss of long-run values arising from basic and evaluative research. But with the trend toward closer scrutiny of public agencies, good evaluation and goal-neutral research will become increasingly important.

David L. Chicoine, assistant professor of agricultural economics

Illinois Businesses

Because of its geography, Illinois has a long history of strong business associations with agriculture. Illinois is a transportation center in road, rail, and water systems, which connect our farmers with national and international markets. Illinois is also home for some of the nation's largest manufacturers of farm machinery and other farm inputs, with markets spanning the nation and the world.

The Agricultural Experiment Station works for Illinois business in two ways: it produces research results, and it provides a facility for hands-on research experience for students whose future prospects include Illinois business.

In its farm-directed research, the Station provides information to improve business's capacity to predict changes on farms and in farm-related sectors of the economy. Research that improves crop performance under reduced tillage, for example, is important for manufacturers and distributors of crop machinery and chemicals as well as for crop farmers. Research in international agricultural development generates better markets for both farm commodities and manufactured farm inputs, in addition to benefiting rural people in developing countries.

Some Station research is directed specifically to Illinois business. Outstanding among recent discoveries here at the Station are new methods for using soybeans in products for human consumption. When successfully adopted, these methods benefit the food-processing industry. They also widen the consumer's range of food choices and strengthen the farmer's market for soybeans. Alternative ways for varying amortization payments, being investigated today at the Illinois Station, may be prominent tomorrow in reducing delinquency and default among farm mortgage borrowers. Lenders, as well as farmers and taxpayers, will be the beneficiaries.

Benefits from farm-directed research are transmitted quickly from farmers through commodity and financial markets. For example, the prices of pork, milk, and milk products are restrained or reduced because of research leading to increased productivity in swine and dairy herds. Improved supplies from increased productivity contribute to lower prices for consumers. U.S. consumers spend a smaller percentage of their incomes for food than do consumers in any other major industrial country, despite the large fraction of U.S. farm products going to export markets. Indeed, technological adjustments are so rapid that public policies are needed to offset associated hardships for farmers. The study of such policies is also high on the research agenda at the Experiment Station.

The Station is an important participant in market research. Timely and accurate intelligence improves the decisions made by farmers and by those associated with them through markets. Station scientists have done pioneer research to identify problems in maintaining the quality of grains in export markets and to suggest remedies for those problems. Benefits from improved standards, processes, and pricing arrangements flow throughout the business community as well as to farmers.

The second major way the Station serves the business community is through helping to educate agricultural students, many of whom are eventually hired by Illinois businesses. The College of Agriculture is widely recognized for the high quality of the educational experiences it offers. Students have daily contact with active scientists, and most students participate in research activities from time to time. Such a unique and dynamic learning experience would be difficult if not impossible to develop without the Station.

Illinois business employs more than a fourth of the seniors graduating from agricultural departments. An even higher fraction of those receiving M.S. degrees and a smaller but increasing fraction of those receiving Ph.D. degrees are hired by business. The Station's role in personnel development is a highly significant contribution to businesses and, through them, to the citizens of Illinois.

Chester B. Baker, professor of agricultural economics

The study of grain movement through various stages of the market channel is essential in preventing economic losses and maintaining quality standards.

Communication Channels

Instruction on Campus

Research projects seldom begin in the laboratory, pen, or field plot, nor do they end there. Before scientists start the task of discovering new knowledge through research, they must identify pressing needs and problems. And when the research is completed, the findings must be passed along to interested audiences through educational and informational programs.

One of several channels for communicating research findings to others is the resident instruction program in the College of Agriculture. Most of the faculty members in this program wear two hats: they serve as researchers and as teachers. Pivotal figures in the land-grant institution, our scientist-teachers help to unify research, education, and public service into a cohesive whole.

With on-going experiments at their fingertips, scientist-teachers are uniquely qualified to provide what pioneer agriculturalist Jonathan Baldwin Turner called "a liberal and practical education." Graduate and undergraduate students benefit from this arrangement. Firsthand, they have the opportunity to see the scientific method in action. They also get a strong sense of the intellectual curiosity that motivates the researchers.

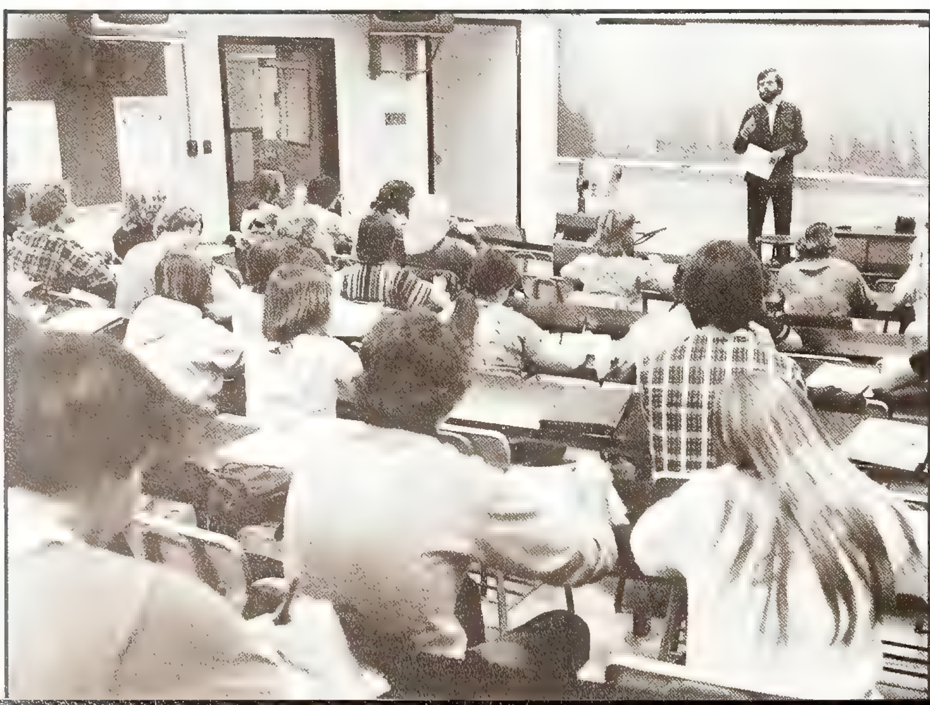
The typical student is concerned with practical applications of research to the "real world." In the classroom the scientist-teacher can explore research findings and applications with students, deal with unanswered questions about research in progress, and get useful feedback.

As horticulturist Robert Skirvin commented: "I find student questions really stimulating. Sometimes they are questions I wouldn't have expected to appear at all. Students will ask something they think is very simple, but which is really a very complex, very profound question. I've enjoyed having students participate in my research."

Students in the College of Agriculture engage in research activities as part of their regular course work and in special research projects. Many are also laboratory assistants to professional researchers in the College. Through this work students gain hands-on experience in subjects related to agriculture, veterinary medicine, human resources, and family studies.

These activities commonly reflect the research interests of the supervising scientist-teacher. However, many of the educational projects go beyond teaching exercises and may, in fact, focus on problems that have a considerable effect on our food supply. Animal science students, for example, use sophisticated equipment and laboratory techniques to determine the nutritional value of animal feeds and protein supplements. These studies encompass such critical areas as amino acid levels, the bio-availability of various nutrients, and specific effects

In the classroom, horticulturist Robert Skirvin finds that students often ask questions that help him fine tune his research.



of diet on the metabolic and the reproductive systems.

In the plant and soil sciences, many students work in greenhouses, laboratories, or fields on projects devoted to the more efficient use of production resources. Typically, plant science students do research in crop variety improvement, genetic engineering, crop protection, and environmental management.

Agronomy students use such complex equipment as the nuclear magnetic resonator to evaluate the genetic potential of seed varieties. Others analyze the performance of crops under varied growing conditions, different soil fertility levels, and environmental stress. Still other students investigate effective pest management techniques, which include the use of monitoring devices for early detection of yield-robbing insects.

In ornamental horticulture, students and scientist-teachers work closely together studying propagation and production techniques for flowers, foliage plants, trees, and turfgrasses. A number of students have been involved in developing improved flower varieties, such as a new chrysanthemum. Using tissue culture, undergraduates learn advanced techniques for accelerating plant propagation. This procedure has been used successfully in propagating fruit trees, strawberries, greenhouse roses, and other plants.

A group of students in urban forestry has developed attractive and functional tree-planting and management schemes for several communities, among them Decatur and Blue Mound, Illinois. In forest management, students who were part of a summer project in southern Illinois have developed a comprehensive forest management plan. Supervised research of this sort not only provides professional training, but also emphasizes the efficient use of valuable natural resources.

College of Agriculture researchers work well in their dual role of scientist and teacher. While disseminating useful scientific knowledge, they nurture the individual student's interest in research. This pattern of interaction is undoubtedly one of the major strengths of the land-grant educational system. We are proud to be part of this continuing heritage.

John R. Campbell, director, Resident Instruction

Agronomist Tom Burger works greenhouse experiments into his teaching activities.

In the Stock Pavilion, students gain practical experience in livestock judging.

With the help of this mobile unit, plant pathologist Barry Jacobsen can identify crop diseases as they occur in Illinois.

Extension at the Grass-Roots Level

The job of the Illinois Cooperative Extension Service, the off-campus educational arm of the College of Agriculture, is to act as a bridge between researchers in the Agricultural Experiment Station and the citizens of Illinois. Although Extension conducts some applied research on its own, its main activity is to bring research findings to people through demonstrations, tours, group meetings, and one-on-one instruction. Our goal is to provide practical information that will help people of all ages solve their problems.

An Old Saw. A story went the rounds some years back about an elderly farmer who listened for a while to a young county Extension agent. Finally the farmer interrupted him and said, "Sonny, I already know how to farm better than I do."

There is probably some truth in his statement for many of us in Extension. We may have the know-how to do a better job, but for some reason we haven't quite gotten around to it. At present, though, we are using all the methods available to us to reach people. Mass media releases and publications of many kinds are two ways that Extension reaches out. Through these and other means we provide unbiased information based on research so that users can apply the new knowledge to improve their lives.

A Grass-Roots Approach. One of the tried and tested ideas of Extension is to deeply involve as many people as possible around the state. Extension believes in the grass-roots approach. Several thousand people serve on Extension Councils and committees in Illinois. Tens of thousands more serve in other volunteer capacities. These leaders help us to identify problems and to develop programs to solve them.

Volunteer leaders also help professional staff members to present programs and to evaluate the outcome. This entire structure provides valuable feedback through Extension to the scientists in the Experiment Station. The feedback in turn helps to ensure the "real world" dimension in research conducted by the Station.

A Long Tradition. Our professional staff, located throughout the state and in Urbana-Champaign, has provided a wide variety of educational services through the years. The Extension program is divided into four areas: agriculture and natural resources, home economics and family development, community resource development and public affairs, and 4-H and youth development.

Three-quarters of a million people participate directly. We can only guess at the numbers of those who receive information through mass media and publications and indirectly through other agencies. Probably the lives of almost everyone in the state have been affected in some way since the Extension program started back in 1914.

Today and Tomorrow. Modern methods are being mixed with the traditional ones. We have telecommunication links to all areas of the state. More are being added. Through the TeleNet system Extension has the capability of bringing specialists and scientists to sites throughout Illinois. Electronic mail is being tested. Videotape playback units are soon to be installed at several locations. And the use of computer software for administration and instruction is gradually becoming an important part of our program.

Extension professionals have a most difficult assignment, one that requires a high level of knowledge, skill, and ability. To be effective, they must be respected by their colleagues in research and by the people they serve. Almost three-fourths of Extension staff members hold an advanced degree. Each semester many of them return to school to take graduate courses. Substantial time and effort are spent on keeping the staff well informed.

Through evaluation we encourage staff members to become more precise in their goals: what, how much, for how many. Extension people are learning to approach the teaching task more scientifically than in years past. With greater precision in goal setting and evaluation, careful attention must be given to ways of realizing those goals: the methods to use, when to use them, in what order, and for whom.

Extension administration is concerned about the proper selection and placement of individuals. But equally important, we continually ask ourselves if the staff is meeting the needs of a changing scene in Illinois.

Are families being well served, and are those with special needs being adequately helped? Are the needs of commerical agriculture being met? Is the youth development activity through 4-H aggressively helping young people to grow? And is our activity in community resource development in tune with the needs of Illinois communities? All of these questions are on our agenda for today and tomorrow.

Robert P. Bentz, associate director, Cooperative Extension Service

Mass Media and Audio-Visual Support

In broadest terms, the mandates that created the land-grant concept define the work of the Office of Agricultural Communications: to make research findings and educational information available to all people of the state.

The challenge is easily stated. But somehow meeting it today seems far more complicated than ever before.

Throughout the years the demand for communication support of research and Extension education programs has increased with the growth of the College of Agriculture and with increasing numbers of interdisciplinary programs such as energy conservation and environmental studies. The constant state of flux in the communication media serving agriculture and Illinois citizens has also placed greater responsibilities on this office.

Traditionally we have concentrated on providing information to newspapers, farm periodicals, radio, and television. The office now provides many services:

- A regular flow of news releases to some 120 daily newspapers and 160 farm periodicals
- A weekly tape service used by more than 90 stations and 5 agricultural radio networks in Illinois and border states
- A biweekly consumer information radio tape service used by 45 stations
- A weekly video-taped gardening-consumer information program aired in all but one of the major television markets in the state
- A daily five-minute farm program that reaches television viewers in 15 counties

In addition, Cooperative Extension Service advisers in all 102 counties receive a weekly packet of educational support materials for release to weekly newspapers. Advisers adapt these materials for local radio and television programs and for newsletters directed to special groups.

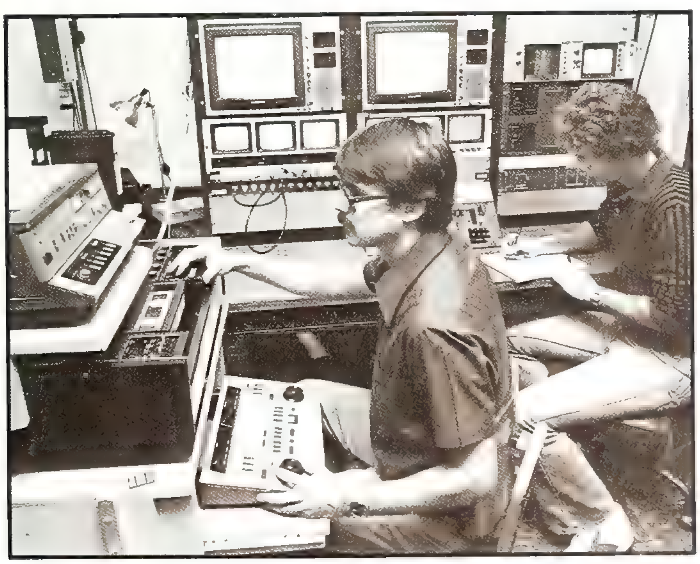
Mass media originating from campus and from county Extension offices extend the reach of the College of Agriculture. During the 1979-80 fiscal year, for example, state and county staff generated more than 20,000 news releases and 11,000 news columns. Staff members were responsible for some 25,000 radio and 1,600 television programs, for a total of 150,000 minutes of air time. Extension staff also produced 3⅓ million copies of more than 6,000 newsletters.

Mass media services remain basic to the goals of the office. But at the same time we have an increased number of requests for support of Extension and the resident instruction faculty. Extension specialists now rely heavily on audio-visuals in their workshops, schools, and seminars.

The statewide TeleNet system has added to the demand for our communicators' assistance. Established in 1970 by the Cooperative Extension Service, the system began as a 17-station, dedicated telephone network with headquarters in the Office of Agricultural Communications. Today, TeleNet provides an effective educational tool that helps Extension reach a wide range of audiences in 75 county offices throughout Illinois. By late fall of this year the network will be essentially complete.

TeleNet is basically an amplified, party-line telephone system. Each station may transmit as well as receive audio messages. When coupled with packaged visual materials, teaching through TeleNet can be conducted almost as if the instructor were in the room.

The system is also used to handle emergency problems; to conduct farm management tours, schools for tax practitioners, and workshops on gardening and landscaping for home-owners; and to offer graduate courses for credit. TeleNet has become an effective means for updating the



Mike Sager and Bill Creswell put the finishing touches on an instructional video program for the College of Agriculture.

Carla Rich (foreground), Marilyn Upah-Bant, and Joan Deutsch in the TeleNet studio.

county staff and for allowing administrators around the state to meet on a regular basis from their own offices.

Video cassettes, another effective tool, have been used since the summer of 1978 to enhance instructional programs in classrooms and in informal Extension educational settings. This medium is a relatively cheap and easy way of providing first-hand observation for learners. For example, students can take a video-taped tour through one of the state's finest confinement facilities for swine and hear from the owner himself without missing a class.

Video tape is also being used by Extension entomologists and plant pathologists to train field scouts in integrated pest management programs. With the system, educational programmers can record problem situations and demonstrate proper scouting techniques in fields where the problems exist and then use the programs at other times of the year.

Video programs are now being produced on topics such as backyard gardens for homeowners, livestock judging for 4-H members, nutritional practices for urban families, the ins and outs of video cattle sales for livestock producers and buyers, and incorporation of preemergence herbicides for farmers. The foundation for a county playback system has been set with the purchase of 20 playback units for county and regional offices. And this is just the beginning.

Reaching the people of Illinois with helpful, research-based information is a major concern of all College of Agriculture programs. New communications technologies have joined traditional mass media in extending the reach of the College. Although situations and technologies change, the basic challenge remains the same: to reach people and to help them learn.

Delbert T. Dahl, head, Office of Agricultural Communications

Publications and the Information Revolution

An unwritten rule of scientific research is that an investigation is not complete until the results have been reported. Research findings that remain only in the mind or notebook of the research scientist are of limited value to society. On the other hand, when those results are presented to the appropriate audience in a clear, accurate, and timely manner, they can have far-reaching effects.

Published research findings can stimulate and guide other researchers working in the same or a related discipline. Often, they can have an important effect on policy-making in government and industry. Results of applied research can be used directly by professionals, farmers, businessmen, and homemakers. And not to be forgotten is the general public, which in today's complex society must be kept well informed about the course and impact of research.

Although scientists are expected to report the results of their work, most have neither the time nor the expertise to carry out the task unaided. Early in their histories, the College of Agriculture and the Agricultural Experiment Station recognized the need to provide professional help in preparing written materials for a wide range of audiences. The College retained its first editor in 1915. Since publication of the first formal Experiment Station bulletin in 1888, more than 750 bulletins have been released and countless other types of publications prepared and distributed.

Currently, the Office of Agricultural Publications employs a staff of eight editors and more than 25 production personnel to help researchers communicate their findings. Working closely with the scientist-authors, the editors analyze the audience to be reached, suggest the best format, guide the preparation of graphs, photographs, and drawings, and ensure that the message is presented clearly and accurately. The editors also attend to the many details involved in getting the message into print, thus freeing the scientists for what they do best — research.

The finished product can take many forms. The latest findings of a research project may be reported to other professionals in a short pamphlet or report and to the general public in the pages of *Illinois Research*. After accumulating a sizable body of knowledge on a particular subject, scientists may present their work in more complete form in a bulletin or book. When a special problem arises, a conference of specialists may be convened to exchange information and seek solutions. Drawn together and published as a conference proceedings, the papers presented at such a meeting can serve as a valuable resource to those who must analyze and solve the problem.

Of course, Experiment Station publications are but one of many channels for disseminating research results. Scientists generally report their work to their colleagues through scholarly journals. The public is kept informed through news releases prepared by the College's Office of Agricultural Communications. Research information that is directly usable in the everyday operation of homes, farms, and businesses is available through Cooperative Extension Service workers, who also rely heavily on publications in carrying out their teaching mission. Communicating research findings is truly a team effort, involving scientists, Extension professionals, communication specialists,

and the media.

Nearly every day we hear more about the information revolution now occurring in our society. With the advent of relatively inexpensive electronic devices for collecting, storing, processing, and transmitting information, our time-honored procedures for distributing research information are undergoing fundamental changes. The tedium of library research has been lessened by the development of computer data bases, which enable researchers and other information users to quickly scan and select available information on a myriad of topics. Word-processing systems — computer-based typing units — are reducing the time and effort required to prepare and revise written materials.

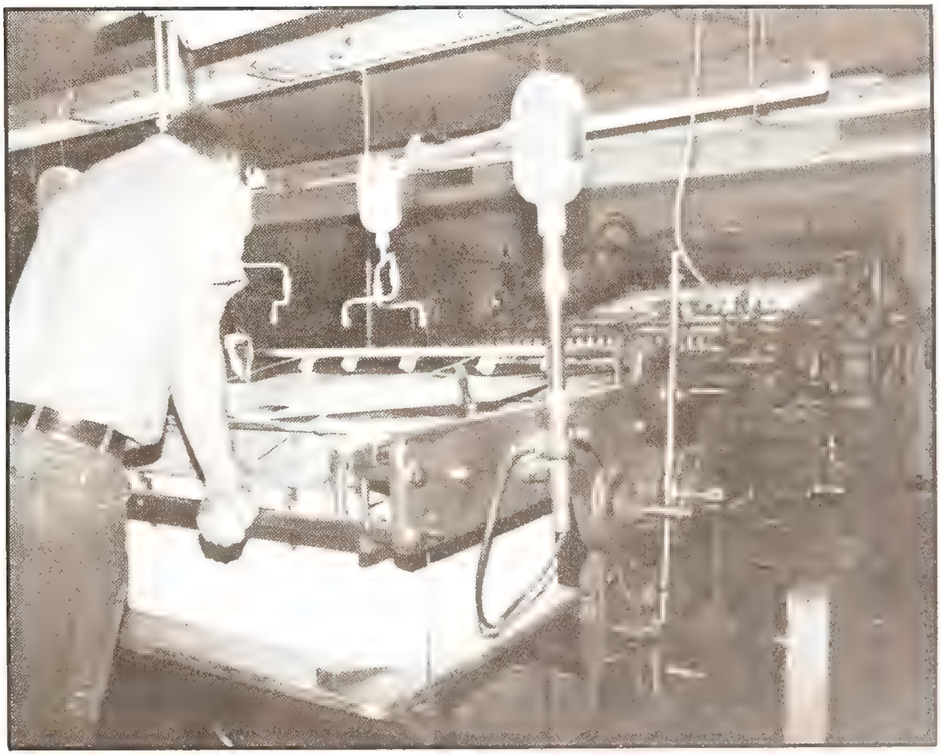
The home computer, now within economic reach of most farms, homes, and small businesses, will make it possible to gain immediate access to massive banks of specialized information. In certain areas of the nation, for example, farmers can now get up-to-the-minute market reports, disease and pest control information, and management tips on video screens in their own offices and homes.

To be effective communicators in the future, research scientists, Extension professionals, and communication specialists must all learn to take advantage of the opportunities offered by the rapidly developing information-processing technology. Printed publications may never be entirely supplanted by electronic devices. But there is no doubt that in tomorrow's world we will rely heavily on information-processing systems to sort and analyze the ever-increasing body of knowledge we need to survive and prosper.

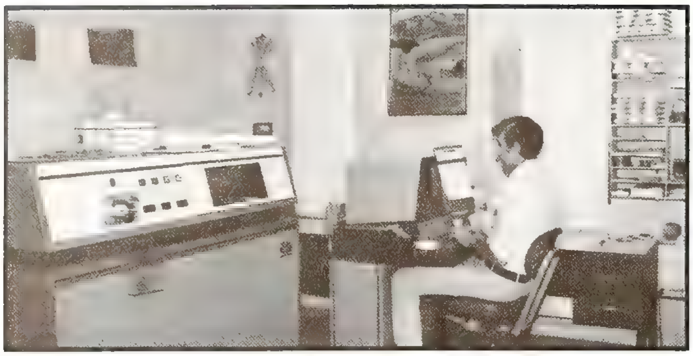
The Office of Publications is taking its first steps toward using this technology and will continue to seek the best methods for assisting researchers in communicating their findings to those who can benefit from their work.

Thomas W. Knecht, head, Office of Agricultural Publications

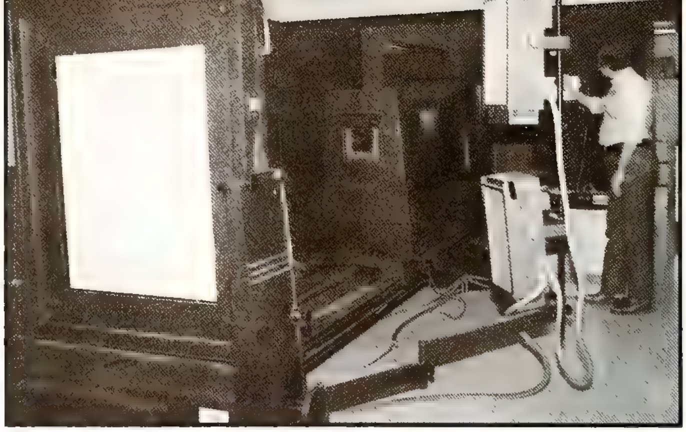
Some publications are still typeset on the Linotype at the University print shop. The machine casts solid lines of type in hot metal melted from the bars to the left of the operator. During its first twenty-three years, *Illinois Research* was set in hot type.



A pressman scrutinizes the quality of each signature as it rolls through the last stage of printing on the flat-bed letterpress. A signature is a large sheet of paper that contains several different pages of text on both sides of the sheet.

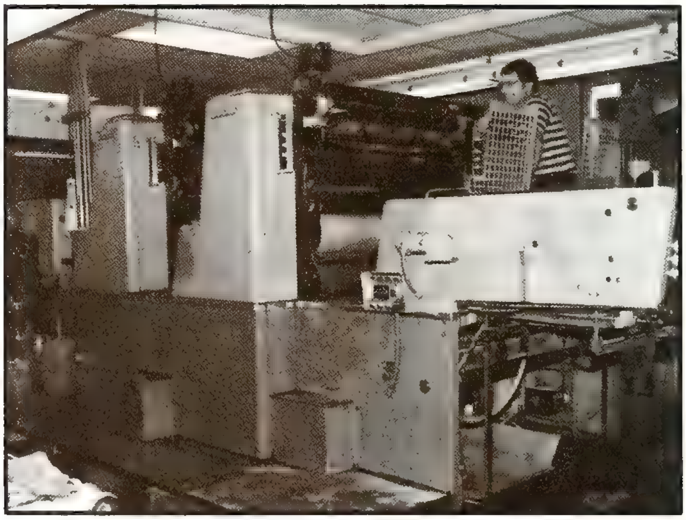


Phototypesetting, with keyboard and output unit located near the Linotype room, is the latest development in typesetting. Compared with hot type, the new photocomp method is more versatile. *Illinois Research* is now set by this method.



A copy camera is in position to shoot a photograph of material held flat against the white copyboard. The inside of the bellows is about twice the size of a kitchen oven.

Negatives from the photographs are then stripped into their proper positions to make a "flat." In a final step, offset plates are made from the flats.



With the plates in position, the offset press is ready to roll. *Illinois Research* is run on this press, which can print two colors at one time.

After printing, the signatures are sent to the bindery, where they are folded, assembled, trimmed, and bound. The machine pictured here assembles perfect-bound books.

Publications are stacked on skids, eventually to be shipped to distribution centers.

Update

1981 Food and Farm Bill

At press time, a new comprehensive food and agricultural policy for the United States is approaching final agreement. For several years to come this policy will have profound effects on consumers, producers, food processors, international trade, conservation of agricultural land, and on agricultural research, extension, and teaching.

Development of the bill was propelled by two forces: first, by the statutory termination with this crop year of the Food and Agriculture Act of 1977, the latest installment in half a century of policy evolution; and second, by unresolved problems in the agricultural and food sector.

Private groups and public institutions, including the College of Agriculture, launched development of the current policy during 1980 with research into the issues, discussions, and communication of results. Congressional attention mounted, until extensive public hearings were held in March and April, 1981, and recommendations were made by the Secretary of Agriculture and other federal executives.

Many farm and nonfarm interest groups, as well as individuals, testified at the hearings. During May, agriculture, nutrition, and forestry committees in both the Senate and the House of Representatives shaped their proposals. When the 97th Congress reconvened in early September, the full legislative assemblages were scheduled to begin making final decisions on the policy proposals.

Immediately following these decisions in late October, a conference committee of both houses was established to strike the compromise provisions. The probability of Presidential approval or veto was weighed during final deliberations. The compromise then had to be accepted by the full Congress and by the President. A tone of urgency prevailed as the October 1 deadline passed and stopgap extensions of terminating policy for wheat and dairy were enacted.

With the impending passage of the new act, economists have begun analyzing its many provisions. The winter issue of *Illinois Research* will take a close look at some of these provisions and their likely consequences for various segments of the economy.

Robert G. Spitze, professor of agricultural economics

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Agricultural Experiment Station
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Nutrition and Society

Human beings have been curious about nutrition down through the ages. Only in the 20th century, however, did we begin to direct this curiosity into the scientific study of food and its relationship to health. Advances in human and animal nutrition have been hailed as one of our finest scientific achievements.

During the earlier part of this century, a great deal of nutrition research was centered on discovering what nutrients are essential and how they affect human health. Such studies of vitamins, for example, have helped us eradicate many deficiency diseases. More recent advances have given physicians the means of providing nutritional support to hospital patients so that they can now recover from illnesses that used to cause starvation.

Yet our past achievements are only a beginning. For instance, the widely publicized progress in medical treatment expected from genetic engineering will probably be modest compared with advances that this new technology will bring in agriculture, food production, and food processing. Agricultural applications may very well support a $100 billion industry by the year 2000.

We will certainly see a worldwide shift in agriculture from a natural to a more scientific resource base. Prospects are excellent that genetic engineering and other technologies will provide new schemes of nutritional and medical management. Not only will recovery from cancer and other life-threatening diseases become common, but applications of new knowledge will also play a major part in disease prevention. The natural links between agriculture, nutrition, and medicine will become more and more evident.

Nutrition has many dimensions: scientific, economic, legislative, social, industrial, agricultural, and public health, among others. At the University of Illinois, interdisciplinary activities in nutrition are facilitated through the Division of Nutritional Sciences under the guidance of the Agricultural Experiment Station and are administered by the College of Agriculture. The Division's purpose is to help the University meet society's research, teaching, and public service needs in nutrition as we approach the 21st century.

This issue of *Illinois Research* contains a report on current knowledge of human nutrition, the Division's work at the frontiers of nutrition research, and future needs in this important area. The authors stress the dependence between proper nutrition and the well-being of infants and adults and summarize recently emerged evidence pointing to diet as a major factor in cancer incidence. The role of diet in relation to important facets of heart disease, immunity, and disease prevention and treatment through diet and exercise are also discussed.

Our hope is that the quality of life for all age groups will improve as people recognize the need to apply the findings of nutritional research to their daily living.

Willard J. Visek, professor of nutrition and metabolism, Division of Nutritional Sciences and College of Medicine

The Cover

Human nutrition begins with food entering the gastrointestinal tract through the mouth. The act of eating triggers a complex chain of interactions between the chemical makeup of different foods and the normal processes that convert nutrients into essential forms for body use. Adequate quantities of these nutrients can enhance human development, longevity, and productivity. With too many or too few nutrients, vitality declines and we become susceptible to disease.

"At a time unlike any in the past, we must envision the future."

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Illinois Research

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Renewal time

To the Readers:

Part of the Illinois Research *mailing list is out of date. We are therefore asking certain readers to renew their subscription at this time. If your issue contains a renewal card incorporated in the special wrap-around cover, please return the card promptly. Those who have not received a notice will automatically be kept on the mailing list.*

Future issues will carry in-depth reports on soil and water resources, research benefits to urban areas, animal agriculture, forestry in Illinois, and crops agriculture. Brief reports of research in progress will also be included. Our goal is to provide both breadth and depth of coverage so that researchers, teachers, general readers, and special audiences can keep abreast of Experiment Station activities.

Readers have sent many letters of encouragement as we begin this new venture in reporting Illinois agricultural research. To keep us on our toes, we ask you to raise questions and make comments about the information presented in Illinois Research. *Letters that meet the criteria for publication will be printed in this column.*

Sheila A. Ryan, editor

Address communications to Editor, Illinois Research, 123 Mumford Hall, 1301 West Gregory Drive, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801

Please limit letters to 250 words.

Nutrition

Developments in Nutrition at the University of Illinois

John A. Milner, Arthur J. Siedler, and L. Ross Hackler

The University of Illinois has a long tradition of excellence in nutrition research and teaching. One of the foremost institutions in this area, the University offers both undergraduate and graduate training in nutrition.

Nationwide, the largest number of competitive CSRS/USDA grants in human nutrition studies has been awarded to the University of Illinois. Most of the nutrition faculty are members of the American Institute of Nutrition, and many have served admirably on various national committees concerned with human health.

The University's reputation as a major nutrition research and education center began in the 1920s with the outstanding work of W. C. Rose in the Department of Chemistry, and H. H. Mitchell and T. S. Hamilton in the Department of Animal Science. Before these recognized giants retired, faculty members had established nutrition-related programs in several departments, many of them in the College of Agriculture. Early developments in nutrition evolved primarily from the strong nutrition programs in animal science and dairy science. Nutrition research undertaken to serve livestock producers continues to make significant contributions to human nutrition and the biological sciences.

During these developments, the College of Agriculture became increasingly aware that improved agricultural production for its own sake was of limited value unless the products were directly or indirectly used in the human diet. It soon became clear that a primary mission of the College was to ensure an adequate food supply to meet human needs. To do so, faculty members had to determine the influence that agricultural practices have on the nutritive content of food. The faculty also had to explore the effects of life-styles and economics in meeting nutritive requirements.

Survey reports had thrown a spotlight on malnutrition in the United States. This information, along with the close connection between nutrient intake and susceptibility to chronic diseases, reinforced the desire of the College to evaluate its role in meeting food needs. Within the College of Agriculture, many departments increased their efforts to address the problem. As a result, strong programs in teaching, research, and public service were built up in the Departments of Animal Science, Dairy Science, and Food Science, as well as in the School of Human Resources and Family Studies through the Department of Foods and Nutrition.

Created in 1948, the Department of Food Science (formerly Food Technology) was an outgrowth of an awareness that the world food supply has critical implications. The Foods and Nutrition Program in the School of Human Resources and Family Studies was approved for departmental status by the Illinois Board of Higher Education in December, 1977. This department trains undergraduate and graduate students interested in human nutrition, restaurant and institution management, and other food and consumer concerns. The mission of these two departments is to foster research programs and to disseminate information that will help ensure a worldwide supply of wholesome, nutritional food at reasonable cost.

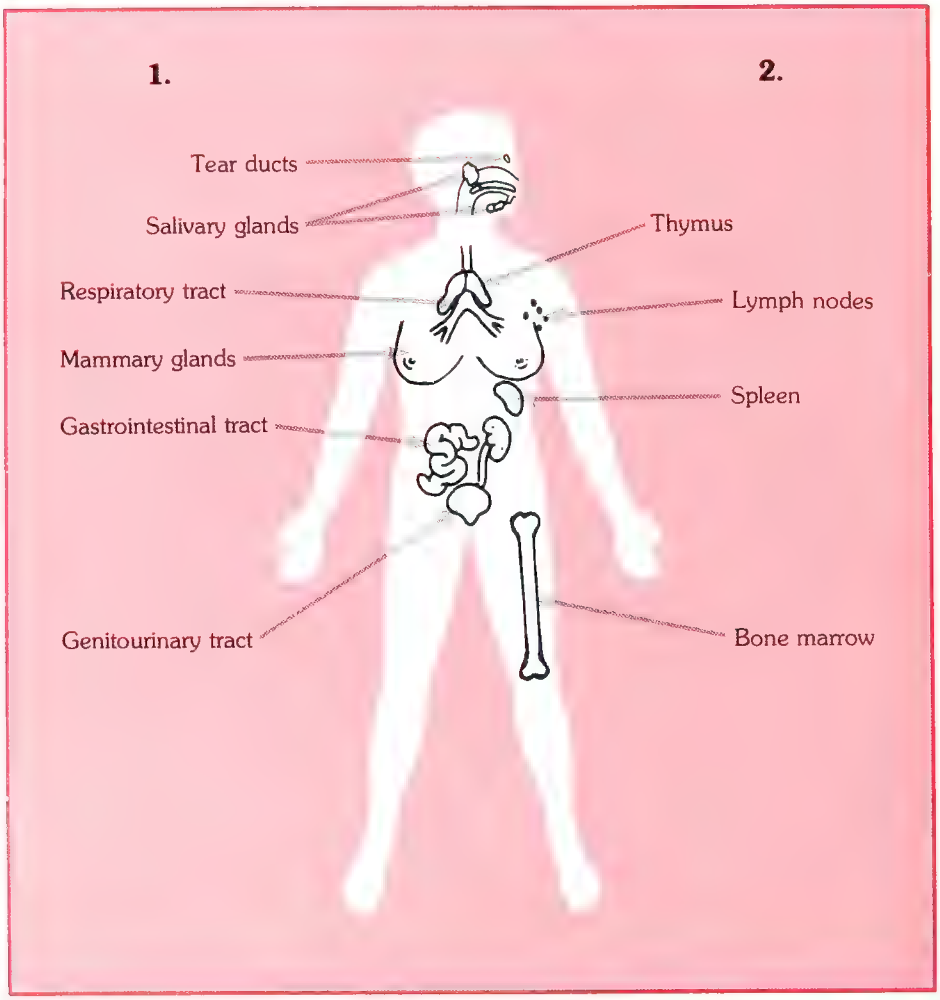
For many years, administrators throughout the University had appreciated that nutrition studies should not be limited to single departments or to a single college. Until 1968, individual departments could offer only their own specialization in nutrition at the graduate level. On December 2, 1968, the Illinois Board of Higher Education approved the development of an interdisciplinary graduate program in nutritional sciences. The program subsequently grew into the Division of Nutritional Sciences, and today it is administered through the College of Agriculture.

From the beginning, the Division of Nutritional Sciences was designed as an interdisciplinary, programmatic approach to research and teaching. Existing faculty became part of the Division, and facilities housed in participating departments were used. The Division offers advanced training at the master and doctoral levels for students seeking specialized education in nutrition. The Division's interdisciplinary nature is reflected in the diversity of participating Colleges: Agriculture, Engineering, Applied Life Studies, Liberal Arts and Sciences, and Medicine. Forty faculty members from these Colleges have been brought together under the umbrella of the Division to facilitate teaching and research.

John A. Milner, associate professor of food science and director, Division of Nutritional Sciences; Arthur J. Siedler, professor of food science and head, Department of Food Science; L. Ross Hackler, professor of nutrition and head, Department of Foods and Nutrition

Nutrition and Immunity

Adria R. Sherman and Patricia V. Johnston



Secretions from organs indicated on the left side of the figure **(1)** bathe their mucosal surfaces and provide a first line of defense against invading organisms. The secretions include bactericidal enzymes, such as lysozyme, and secretory immunoglobulins. Organs indicated on the right side of the figure **(2)** are sites of lymphocyte formation and maturation. When the host is confronted with an antigen, immunocompetent cells are released into the circulation.

Many years ago clinicians recognized that nutrition affects immunity. Not until rather recently, however, did we begin to learn how particular nutrients are involved in the immune process.

When functioning properly, several complex systems work together to protect the body from foreign invaders such as bacteria, fungi, viruses, and cancer cells. Skin and mucous membranes, for example, provide protection by keeping invaders from entering the body. If they do gain entrance, specialized white blood cells called leukocytes mobilize, producing various immunological responses. The body, in effect, has an army of defenders.

Like the different branches of the military, several subsets of leukocytes cooperate to protect the host. Specific immunological responses come from a two-component system (Fig. 1). One component consists of T cells, which are responsible for cell-mediated immunity. The other component is made up of B cells, which produce and circulate antibodies.

A third type of cell, the macrophage, is a surveillance cell. It resides in lymphoid tissues such as spleen and lymph nodes, where it awaits the arrival of foreign matter, known as antigens, in the blood. The macrophage then processes the antigens and presents them to T and B cells, which respond only to specific types of stimuli. In this capacity, the macrophage serves an important regulatory function in the immune system. Some specialized macrophages are killer cells (phagocytes) that directly destroy antigens.

Undernutrition. Mild, regulated undernutrition or maintenance of leanness does not hamper the immune response. In fact, a good deal of

evidence indicates that this is a desirable state and that leanness contributes to an effective immune system, general well-being, and longevity. Once a clear deficiency of certain nutrients exists, immune responses will become impaired.

A severe deficit of proteins and calories is accompanied by gross and histological changes in lymphoid organs such as the thymus. In malnourished children this organ is atrophied. The spleen and lymph nodes undergo changes in size, weight, architecture, cellular components, and fine structure, as seen under the electron microscope.

The effect of these changes on cell-mediated immunity can be tested by skin reactions to streptococci, tuberculin protein, common fungi, and other antigens that people are likely to have encountered sometime in their lives. With undernutrition the test reaction to an antigen is impaired. This indication of a decline in cell-mediated immunity is confirmed by T cell counts that are often low and by the decreased capacity of T cells to divide in response to stimuli. B cell counts, however, are either normal or elevated during chronic energy-protein deprivation.

Levels of some immunoglobulins, the family of proteins to which antibodies belong, are also elevated. But these counts are difficult to interpret, because malnutrition and infection usually occur together. Increased counts could indicate that a person has an active infection or has developed an immunity to a previous one.

Dietary fats are nutritionally important not only as a source of calories and as carriers of some vitamins, but also as a source of linoleic and alpha-linolenic acids, essential fatty acids that the body must have to function prop-

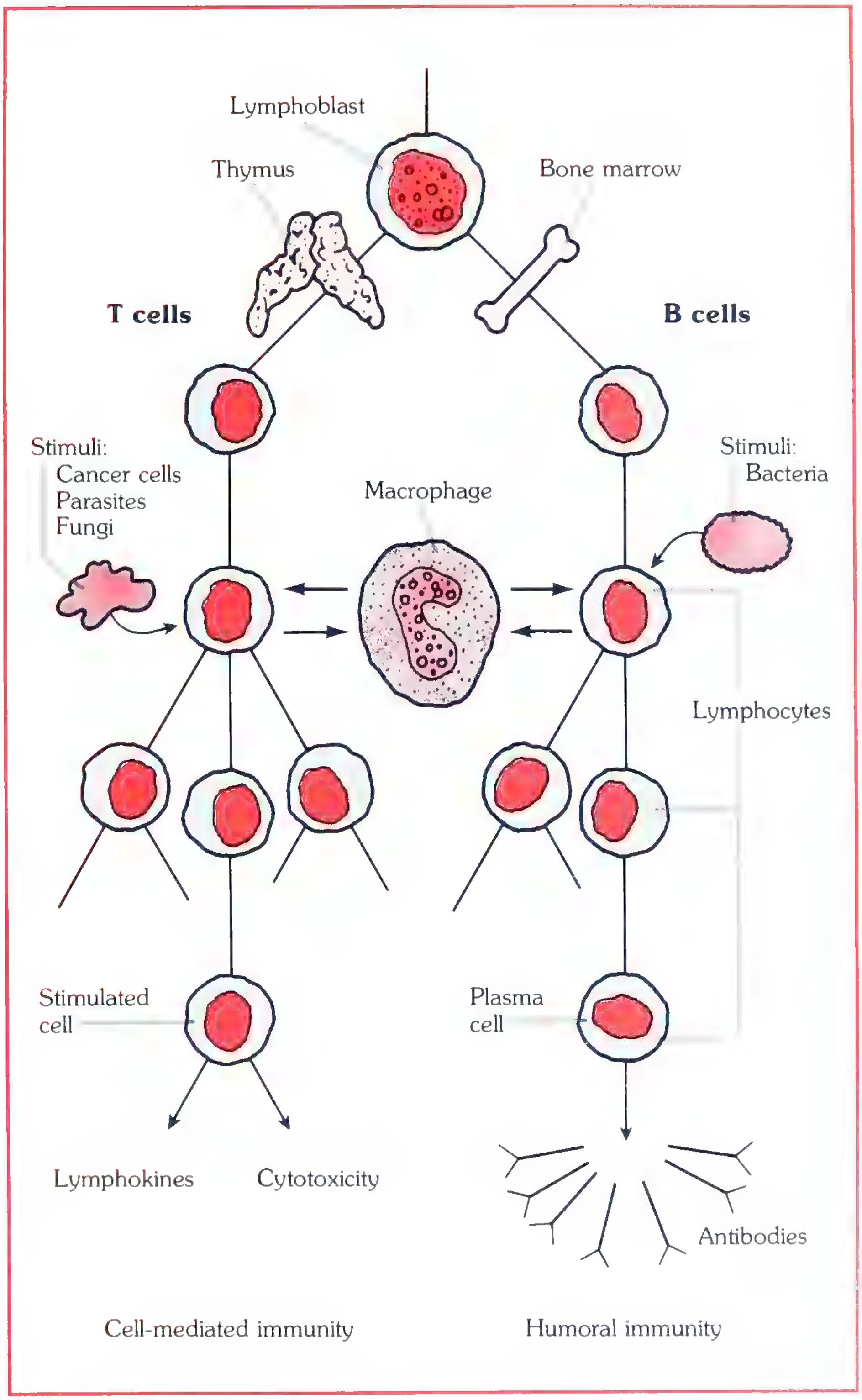


Fig. 1. The two-component immune system and macrophages. **Cell-mediated immunity:** Primitive cells called lymphoblasts enter the thymus, where they are "educated" and become mature T lymphocytes. Upon stimulation by antigens such as cancer cells, the T cells divide and form clones that recognize the same antigen. When again stimulated, the T cells produce soluble substances called lymphokines, which regulate other cells of the immune system and help kill the antigens (cytotoxicity). **Humoral immunity:** Similarly, B cells mature in the bone marrow, are stimulated by bacteria, and become antibody-producing plasma cells that coat and kill invading bacteria. **Macrophages:** These are the surveillance cells of the system and reside in lymphoid tissue such as the spleen. They recognize antigens and present them to T cells and B cells. T cells, B cells, and macrophages can have supportive or inhibitory effects on each other.

erly. Since the body is unable to make them, they must be provided in the diet. The essential fatty acids occur mainly as constituents of common vegetable oils such as corn, cottonseed, and soybean. Arachidonic, a fatty acid that can replace linoleic, is found in meat fats.

These fatty acids are required for building cell membranes and for producing prostaglandins, which are hormone-like substances that affect all cells in the body. A deficiency of linoleic acid leads to dermatitis, poor wound healing, growth failure, and water loss from the skin. Clinical signs of alpha-linolenic acid deficiency have not yet been identified.

In the Division of Nutritional Sciences here at the University of Illinois, the Johnston research group is interested in the essential fatty acids, since they and the prostaglandins are involved in the immune response. Learning more about their role should enable us to help people whose metabolic machinery is unable to utilize fatty acids effectively in the production of prostaglandins. We may also learn how to use fatty acids judiciously to enhance immunity in post-surgical patients or to inhibit it in organ transplant cases to help prevent rejection.

At present we are testing a theory that may explain how prostaglandins turn the activity of the watching macrophages on and off and if it can be influenced by dietary fatty acids (Fig. 2). We have already found that we can control prostaglandin production in the macrophages of experimental animals. We are now examining how production affects the ability of macrophages to respond to invading antigens.

In other studies, the relative levels of linoleic and alpha-linolenic acids in the diet are varied to examine the competition between them for the enzymes that produce prostaglandins. The prostaglandins from each of these essential fatty acids may have a different potency for modulating the immune response. If so, we might be able to control the response of T cells, B cells, and macrophages to antigens. Many established methods are used to assess the function of immunocompetent cells.

At present the immune response is modified mainly by drugs, all of which have side effects. But the day may be approaching when we can replace or supplement drug therapy with diet therapy.

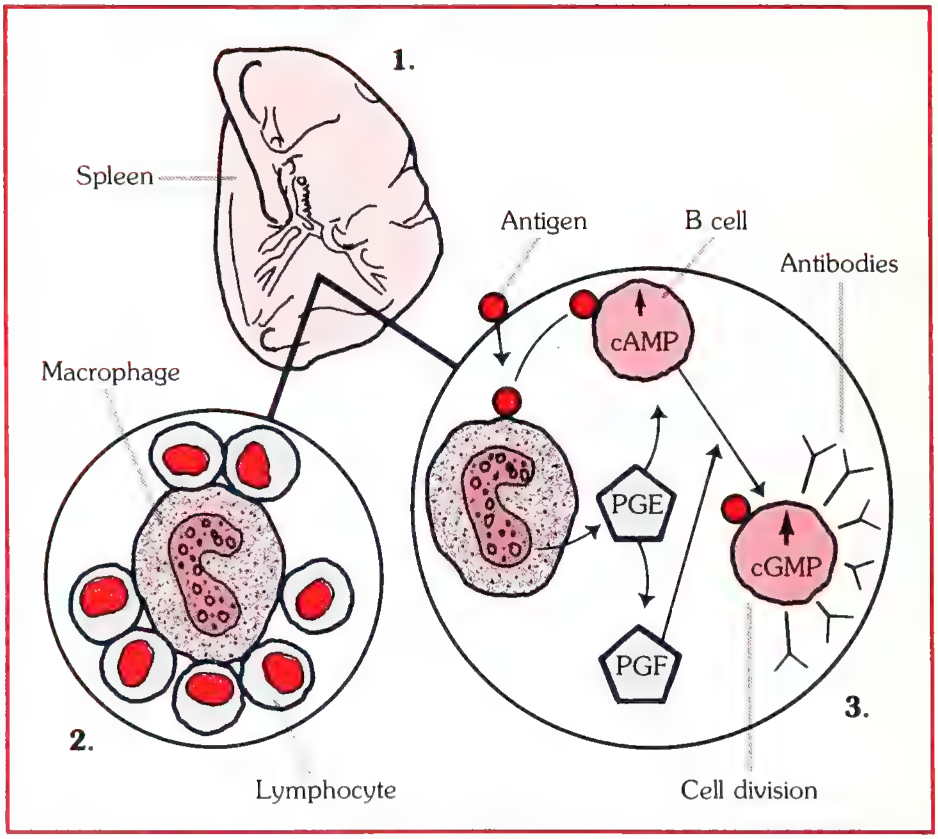


Fig. 2. The macrophage and what it does. Antigens in the bloodstream are collected and processed by lymph organs such as the spleen **(1).** These organs have an architecture that is ideal for processing many different antigens and quickly presenting them to B and T lymphocytes. Processing involves cells called phagocytes (phago = eating; cyte = cell). In lymph tissue, large phagocytes called macrophages contact lymphocytes and present the antigens **(2).** Control of the start of an immune response is not understood, but according to a theory now being tested **(3),** an antigen approaches the spleen, attaches to a macrophage, and is presented to a B cell. The response may or may not start, depending on the relative levels of cyclic nucleotides in the B cells. Cyclic (c) nucleotides are compounds that control cell division. If the compound cGMP is high (↑) relative to cAMP, the B cells divide, producing antibodies. Control of this process may be achieved by prostaglandins produced by the macrophage. Prostaglandin E (PGE) starts the response, and prostaglandin F (PGF) elevates the level of cGMP, thus increasing the response.

Overnutrition. Too much food, as well as too little, can be detrimental to health. It has been known for a long time that obese people do not handle infection as well as those who are lean. In studies of obese children, cell-mediated immunity and phagocytic function were found to be impaired. Overfed dogs showed a greater incidence of disease and increased mortality when challenged with infectious agents. And genetically obese mice have a reduced thymus and spleen weight and impaired cell-mediated immunity. Some of these effects appear to be due to a hormone deficit in the thymus, which is responsible for the maturation of T cells.

Vitamins. Deficiencies of specific vitamins have also been associated with impairment in the immune response. Two vitamins, pyridoxine and ascorbic acid, can be singled out to illustrate the point.

In laboratory animals fed diets deficient in pyridoxine, also known as vitamin B_6, the lymphoid organs show signs of marked immune incompetence. For example, the thymus, spleen, and lymph nodes are smaller and not as well developed as organs from animals fed adequate levels of pyridoxine. Because of underdeveloped lymphoid tissue, pyridoxine-deficient animals are less able to mount an immune response to infecting stimuli. Deficient animals have decreased cell-mediated immunity and are slow in producing antibodies.

Severe deficiency is uncommon in humans, but pyridoxine status may be less than optimal in several population groups. For example, pregnant women and those using oral contraceptives need more pyridoxine than usual. Alcoholics are also at risk of developing a deficiency because of generally poor diets. Muscle meats, liver, and whole grain cereals contain high levels of the vitamin.

Ascorbic acid, or vitamin C, probably serves to maintain the metabolic and functional properties of phagocytes. Taking large doses of ascorbic acid has become a popular home remedy for the common cold. But it appears that a normal diet containing citrus fruits, tomatoes, and other fruits and vegetables supplies adequate levels.

When too little vitamin C is provided in the diet or when too much is taken in supplement form, phagocytic function may be impaired. Thus, the practice of taking very large doses may actually inhibit one part of the body's bactericidal army.

Minerals. Several minerals, among them iron, have been linked with the immune response. Iron deficiency is perhaps the most widespread nutritional deficiency in the United States and in many other countries as well. The problem is common in women of child-bearing age because of iron loss in menstrual blood, and in young children, whose requirement is high because of rapid growth. The relationship between iron and susceptibility to infectious disease is complex and at present incompletely understood.

Many studies reported in the literature have noted increased infections in iron-deficient groups. Other studies, on the contrary, have found that iron deficiency suppresses active infection. Furthermore, excessive iron introduced through the diet or by injection may actually stimulate the growth of invading microorganisms. The apparent contradictions may arise from the experimental conditions. It is virtually impossible to document that iron was the single nutritional, health, or environmental variable that differed between the human populations studied.

Much of the previous research has focused on cell-mediated immunity. Current research in Sherman's laboratory at the University of Illinois approaches the study of iron status and immunity from a different viewpoint. Using a clearly defined experimental model in which dietary iron is the only variable, we are examining specific components of the immune response. In some studies, gradations of iron deficiency and iron overload are created in young, growing rats. In other experiments, the relation between maternal iron status and the development of immunocompetence in the young is being investigated.

Most of the components of the immune response under investigation are involved in the host's first line of defense against invading microorganisms. Of particular interest are factors related to mucosal immunity (see diagram of the human body). The mucosal surfaces lining the oral, gastrointestinal, and genitourinary tracts are bathed in secretions containing substances that incapacitate invading organisms and prevent their entry into the rest of the body. Among these bactericidal substances are the enzymes lysozyme and peroxidase. Other proteins with immunological capacity are being studied in blood, milk, and lymphoid organs. Eventually, results of our research may be helpful in formulating policies for dietary iron supplementation and for the treatment and prevention of iron deficiency anemia.

Many people throughout the world and some populations in the United States suffer the effects of impaired immune responses because of malnutrition. But the average, healthy person who can afford a well-balanced diet has no need to use supplements to enhance these responses. Clearly, the key to optimal efficiency of the immune system and to well-being in general is optimal nutrition.

Adria R. Sherman, assistant professor of nutrition; Patricia V. Johnston, professor of food science

Special Considerations in Infant Nutrition

Terry F. Hatch
and Mary Frances Picciano

The type of food that infants eat may very well influence their health and well-being as adults. This realization brings home the importance of good nutrition during infancy. While in this critical stage of life, all infants are vulnerable to nutritional insult because they are developmentally immature, grow rapidly, and consume a limited variety of foods. Those infants born prematurely or with evidence of intrauterine malnutrition are even more vulnerable.

Studies in infant nutrition at the University of Illinois focus on several areas: special nutrient requirements, the composition of different kinds of milk, the age when solid foods should supplement milk diets, and factors that influence the composition of human milk. Continued research in infant nutrition is of paramount importance if we are to provide sound scientific bases for feeding recommendations.

In infancy, humans need more calories per pound of body weight than at any other time of life. Moreover, this requirement shifts considerably with the infant's age (Fig. 1). During the first four months, the 7.7 pounds of new tissue formed consists mainly of water and fat, while proteins account for only about 11 percent of the total. From four months to one year, the infant again gains about 7.7 pounds, but now the gain represented by protein is 21 percent. The dietary protein requirement increases accordingly after four months of age.

Composition of different diets influences the changes in body composition. Lipids account for the largest percentage of weight gain in infants with high caloric intakes. Low protein intakes are associated with water excess and decreased bodily lipids and proteins.

Human milk is the ideal food for a young infant, provided the mother has a nutritionally adequate diet.

Additional light is shed on the unique problems of infant nutrition by examining the development of the gastrointestinal tract. Between 4 and 6 weeks of gestation, the gastrointestinal tract can be identified. By 16 to 18 weeks, mature intestinal villi can be seen; villi are tiny fingerlike projections that aid in the absorption of food.

Swallowing is present by 18 weeks and sucking by 28 to 30 weeks of gestation. However, the sphincter (valve) that closes the lower part of the esophagus may not function adequately until one year after birth. Digestive function matures from mid-gestation to one year. The ability of an infant to digest and utilize dietary nutrients parallels these developmental patterns (Fig. 2).

Digestive enzymes are produced by the activity of several organs. Until this activity has matured, certain foods cannot be properly digested. Complex carbohydrates such as starches, for example, are hard to digest until four months after birth. By this time the activity of pancreatic amylase has matured enough to aid in digesting these components of food.

Infants weighing less than 5.5 pounds at birth present special problems. Preterms with normal growth, as well as infants who have experienced intrauterine malnutrition, have digestive troubles because certain metabolic pathways are not yet developed.

Unlike functionally mature infants, the preterms are unable to synthesize some nutrients. For example, in these infants there is an impairment of energy generation from fat, possibly because of insufficient synthesis of carnitine, a compound needed to transport fats for cellular utilization. Nutrients that cannot be synthesized by the body must be supplied directly in the diet. We are currently studying fat utilization in low-birth-weight infants and determining the benefit of supplemental carnitine.

Recent trends in infant feeding practices have raised concern. An estimated 20 percent of infants in the United States are initially breast-fed. By six months the percentage declines to 5 percent, and by one year to less than 1 percent. Although recent local surveys indicate that the rate of breast-feeding is increasing, the fact remains that most infants still receive a formula preparation.

Formulas with a base of cow's milk are fed to nearly two-thirds of the infants in this country during their early months, while 19 percent are given milk-free formulas. By the end of the first year, fresh cow's milk is consumed by about 96 percent of all infants. The quantitative and qualitative differences among the various milks and the metabolic consequences of their use are of nutritional concern. Several examples will illustrate this point.

The protein content of human milk is 0.8 to 0.9 gram per 100 milliliters, as determined by amino acid analysis. Milk-based formulas contain about 1.5 grams of protein per 100 milliliters, and milk-free formulas between 1.86 and 2.2 grams. The levels of protein

in commercially available formula preparations are at least 40 percent higher than levels found to be adequate in clinical studies.

The quantity of protein ingested is directly related to serum urea levels; urea is the end product of protein decomposition. Compared with breast-fed infants, those who are formula-fed have higher serum urea values and more concentrated urine. In times of stress, they may be challenged by this increase in urea excretion and the concomitant decrease in free-water excretion.

Proteins, which are basic to all forms of life, are highly complex molecules made up of amino acids. Although there are only twenty amino acids, any number of them can arrange themselves into seemingly limitless combinations, and each combination affects a particular function of the body. Therefore the composition of protein is important in evaluating the differences between human milk and formula preparations.

Casein-predominant formulas provide more of the amino acids tyrosine and phenylalanine than do human milk and the whey-predominant formulas. But two other amino acids, cystine and taurine, are more plentiful in human milk than in cow's milk or formulas prepared from it.

In preterm infants given formulas, researchers have noted elevated plasma concentrations of tyrosine and phenylalanine. On the other hand, in infants fed human milk the plasma concentrations of taurine are elevated and utilized principally to conjugate bile acids. Conjugated, or combined, bile acids are necessary for proper fat digestion. In formula-fed infants these bile acids tend to combine with glycine. We do not yet know the

Authors Picciano and Hatch, shown here at Carle Hospital in Urbana, are studying the complex nutritional needs of infants. Throughout these studies, infants receive routine pediatric care, in-depth monitoring, and nutritionally adequate diets.

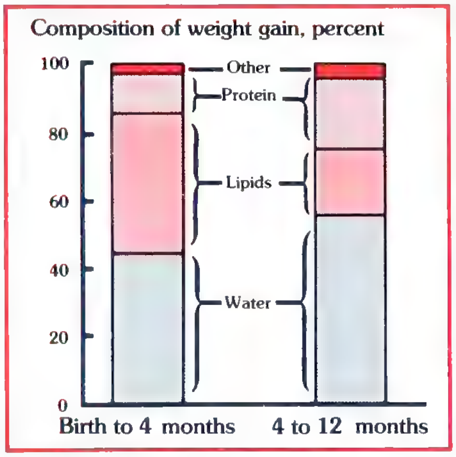


Fig. 1. Composition of weight gain in male reference infant. After 4 months, protein accounts for an increasing percentage of new tissue formed. Dietary protein requirements show a corresponding increase.

Infants that are born prematurely have special nutrient requirements because developmental immaturity alters their ability to utilize nutrients.

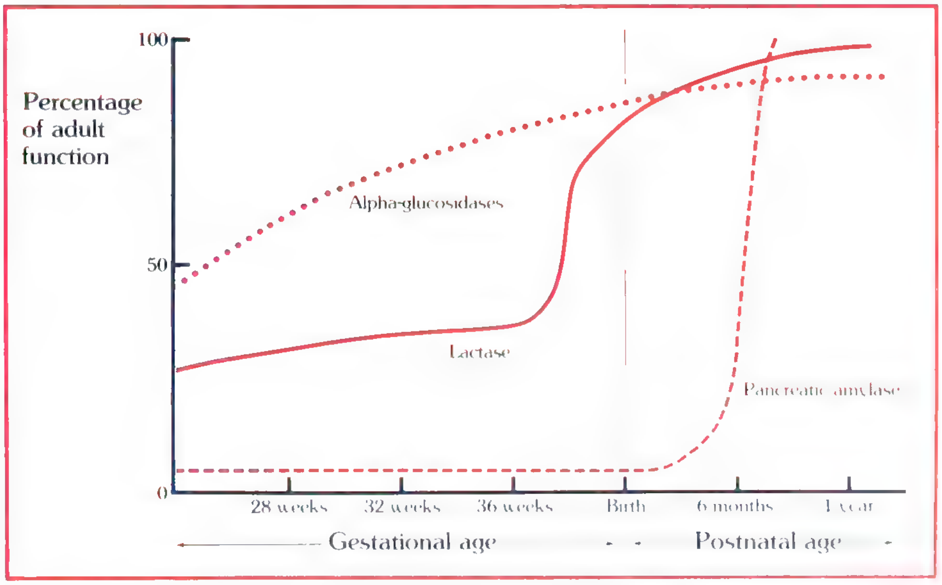


Fig. 2. Development of gastrointestinal enzymes in infants. Before enzymatic activity has matured, infants have difficulty digesting certain foods.

physiological significance of these different combinations in newborns. At present we are studying protein metabolism in full-term infants and the benefits of providing formula-fed infants with an amino acid composition comparable to human milk.

Trace mineral requirements raise another set of questions that need investigation. For example, we recently found that selenium intakes and serum levels were significantly higher for breast-fed than for formula-fed infants. Other researchers have reported that calcium and phosphorus imbalances in some formula-fed infants are related to episodes of neonatal tetany (muscle spasms). In our laboratory, we are now trying to determine whether low selenium levels are implicated in the physiological functioning of infants.

Another area of concern is the early introduction of solid foods, which some researchers suggest may increase the caloric intake. Solids may also provide too many dietary constituents, such as sodium, that must eventually be excreted, thereby taxing the immature kidneys of infants. Unnecessary calories could place infants at risk of developing obesity persisting into adulthood. Moreover, the excess solutes in those calories could be a predisposing factor in the development of hypertension later in life. However, we don't have enough information about the extent to which solids supplement or replace a milk diet or whether they in fact generate excess metabolic products that have to be excreted.

To help fill in this gap in our knowledge, we recently did a survey of a select group of infants. We found that the food items and the time of their introduction into the diet varied considerably with the type of milk consumed. By 12 weeks, formula-fed infants were receiving a wide variety of solids, whereas the breast-fed infants were being given only cereal, fruit, and juice (Fig. 3). Furthermore, caloric intake of infants in our study did not increase significantly with the addition of solids, which seemed to replace milk rather than supplement it.

We did not note any differences between the groups of infants in plasma concentration and sodium, despite the significantly higher solute load imposed on the kidneys by the diets of formula-fed compared with totally breast-fed infants. At 8 and 12 weeks, salt intakes of formula-fed infants exceeded the advisable intake whether or not solids were being consumed. Since salt is no longer added to commercial infant foods, sodium can be further restricted only by reducing the amount in homemade infant foods and formulas.

Thus nutritional factors other than sodium and caloric intakes must be taken into account when recommending that solids be added to a milk diet. Protein appears to be a major limiting nutrient in infancy. Trace element nutrition, still largely unexplored, must also be considered in feeding recommendations.

Finally, the composition of human milk as the model for infant feeding is a pivotal nutritional concern. Most nutritionists and related health professionals agree that human milk supplies the most suitable nutrients for young infants. But this is so only if the maternal diet is adequate and if the infant gets enough milk.

We cannot assume that women in the United States have nutritionally adequate diets. Nor can we ignore non-nutritional factors that influence the composition of human milk. Recently it was reported that long-term users of oral contraceptives show inadequate vitamin B_6 nutriture and low levels of B_6 in their milk. Central nervous system disorders were observed in three infants nursed by such mothers. To reverse the neonatal symptoms, the mothers were given B_6 supplements of 20 milligrams per day, ten times the recommended amount for lactating women.

Research is urgently needed to delineate the maternal factors that influence human milk composition. We also need to explore the relationship that different milk constituents have to growth and performance of nursing infants. At present we are pursuing this line of inquiry for several trace elements and folic acid, one of the B vitamins.

Terry F. Hatch, assistant professor of clinical pediatrics and of pediatric nutrition; Mary Frances Picciano, associate professor of nutrition

Infants must have all required nutrients to meet the critical needs of rapid growth.

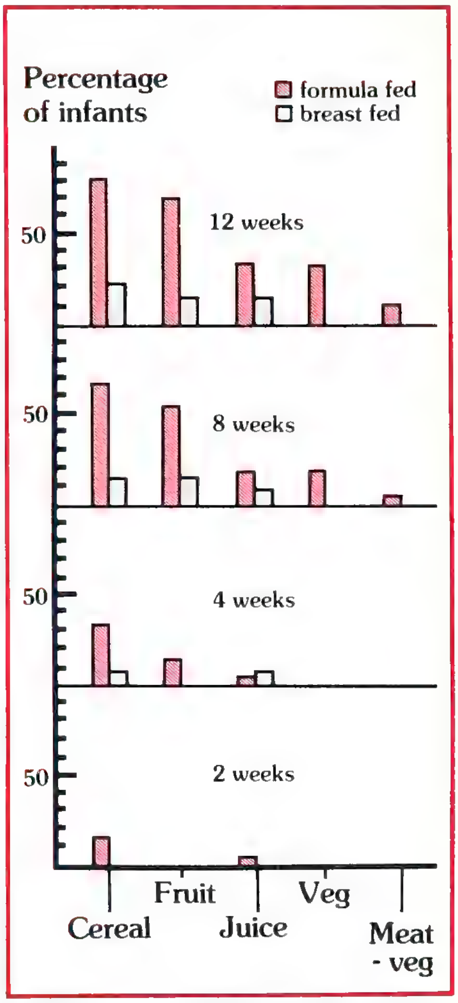


Fig. 3. The types (varieties) of solid foods and the extent of their use differ among formula-fed and breast-fed infants.

Nutrition, Exercise, and Weight Control

Donald K. Layman and Richard A. Boileau

Exercise and diet are important means of controlling weight. On the face of it, this statement may seem obvious enough. But is it?

The type and regularity of exercise, the kind and amount of food eaten, and a person's unique body composition must all be taken into consideration in planning a health maintenance program. The details of such a program will be considerably different for a young male athlete and a middle-aged woman. Through research at the University of Illinois we are gaining scientific insight into the interlocking effects of diet, exercise, and body composition on the state of an individual's health.

Even when the body is at rest, the cells constantly produce energy for normal functions and assimilate new material to repair tissues. Basal metabolism, the name for this process, seems to be controlled by the relative amounts of skeletal muscle, fat, and other constituents that make up the total weight of the body. The importance of muscle in controlling metabolism cannot be over-emphasized.

During childhood and adolescence, the levels of metabolic activity are high, because growth requires substantial amounts of energy and building materials. During the adult years, metabolic acitivity declines to a level that is adequate to maintain the body.

In the maintenance period, the amount of muscle usually decreases, causing a decrease in the basal, or resting, metabolism. There is a corresponding decrease in energy use. We have found that the progressive loss of muscle mass is in part due to a decrease in the number of muscle cells.

Along with the decrease in muscle mass, body fat tends to increase. The transition from youth to adulthood is typically accompanied by a slow weight gain that continues throughout most of the adult years.

Increased body weight, and particularly increased body fat, are directly correlated with increased health risks and decreased life span. Among the most common nutrition-related diseases that appear during the adult years are obesity, heart disease, and diabetes. Each of these is characterized by problems in energy metabolism, especially utilization of dietary fat and simple sugars.

A person's muscle mass, as well as the level of physical activity, must be included in the picture when calculating dietary protein and calorie requirements. Skeletal muscle accounts for 40 percent of adult body weight and 45 percent of total body protein. During vigorous exercise, these muscles use more than 90 percent of the total energy expended by the body. Even while at rest, muscle accounts for a third of the energy used.

The rate at which protein is synthesized in skeletal muscle provides a reliable basis for determining how much protein is needed in the diet. Using growing rats, we found that the minimum level of dietary protein required to achieve maximum protein synthesis is sufficient to achieve maximum muscle growth and development. Other researchers have shown that excess dietary protein shortens the life span. Insufficient dietary protein, on the other hand, retards growth and increases body fat. Thus, precisely defining dietary protein intake related to muscle development is desirable.

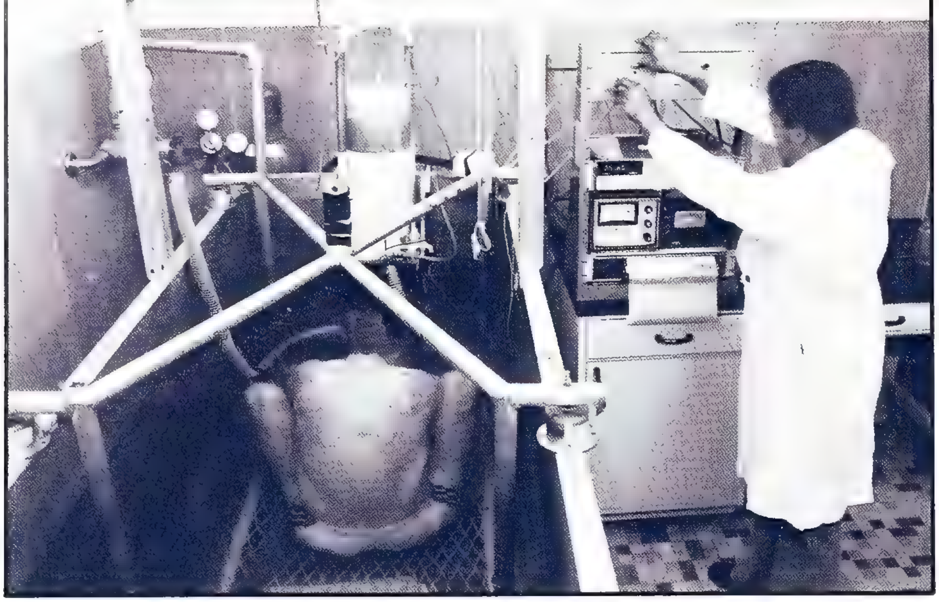
Routine exercise is an effective way to decrease fat and maintain muscle.

The rate at which energy is expended by the body is also highly dependent on skeletal muscle. When exercising, a person can use significant amounts of energy. Walking, for example, requires 300 kilocalories per hour and competitive running 1,000 kilocalories. When at rest, the muscles continue to use energy for metabolic processes such as synthesis of proteins. Protein synthesis alone may account for 15 percent of the total energy used by the body.

In laboratory experiments we have shown that during the transition from growth to maintenance the rate of protein synthesis decreases 50 percent. This change should cause a corresponding reduction in energy use. We have in fact found that in the genetically obese Zucker rat, which is used as a model for human obesity, a major metabolic abnormality is a decreased rate of synthesis of muscle proteins. Compared with its lean counterpart, the obese rat has smaller muscles, uses less energy for muscle metabolism, and stores a greater proportion of dietary energy as body fat.

Quantifying the composition of the human body is important in assessing a person's nutritional status. Body weight can be divided into two basic components: fat and fat-free weight. Fat-free weight, or lean body mass, is roughly equivalent to muscle mass. A person's ideal weight is often based on actual weight in combination with age and height. But such a method does not provide information about the relative composition of the body weight and can lead to large errors in evaluating whether someone is overweight or underweight.

Athletes, and football players in particular, are often classified as overweight because they exceed the



The weight of the body under water provides an accurate measure of relative fatness and leanness.

Skinfold mesurements help to determine the percentage of fat and fat-free weight.

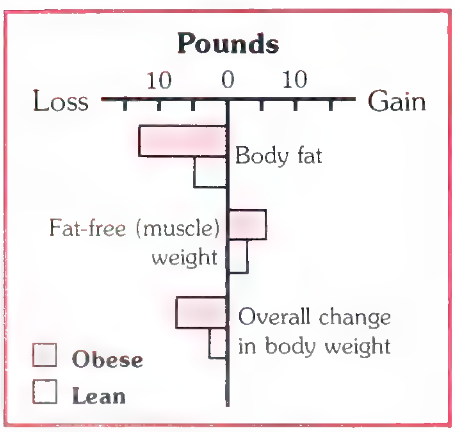


Fig. 1. Change in body composition of obese and lean subjects during 10 weeks of physical training.

ideal weight listed in a conventional height-weight table. Actually they are overweight because of additional muscle mass, not excess body fat. A more accurate measure of how much an individual should weigh takes fat and fat-free weight into consideration.

Several techniques for measuring fat and fat-free weight are available for assessing body composition. The techniques used at the University of Illinois include measurements of skinfold thickness; body density, body potassium, or body water; urinary creatinine excretion; and basal metabolic rate. Skinfold thickness is perhaps the most widely used measurement for clinical screening; however, body density is considered the most accurate.

According to Archimedes' principle, density is determined from measures of body weight in the air and under water. Briefly, body fat, which has a density of 0.9 gram per cubic centimeter, will float in water. Fat-free tissue, which has a density of 1.1 grams per cubic centimeter, will not float because it is heavier than water. Therefore, body density can be used to determine relative fatness and leanness and the ideal body weight.

Exercise is an effective way to control weight and to change body composition. Our research has shown that people who are physically active have a higher ratio of fat-free weight to fat. In a 10-week study of the influence of jogging on body composition, we found that both lean and obese subjects who exercised five days a week at 400 kilocalories per session succeeded in decreasing body fat while increasing fat-free weight (Fig. 1).

One of the ways that exercise influences body composition is through energy use. At peak exercise levels a person can increase his or her metabolic rate 20 times above resting values. This increased rate of energy use remains high for substantial periods following exercise. Moreover, the body may need some exercise to regulate appetite adequately. It appears that exercise has a double-barrelled advantage: it is essential in helping us use calories from the diet and in controlling the number of calories we eat.

Results from these studies indicate that people can favorably modify body fat and muscle mass by participating regularly in an appropriate exercise program. Without exercise, body fat can be shed by restricting the number of calories in the diet. But in this case, fat-free weight or muscle will also decrease because of a loss in protein and water.

With both exercise and caloric restriction, however, the fat-free body is maintained and may even increase. As a bonus, exercise improves cardiovascular functions such as the delivery of oxygen to the working musculature.

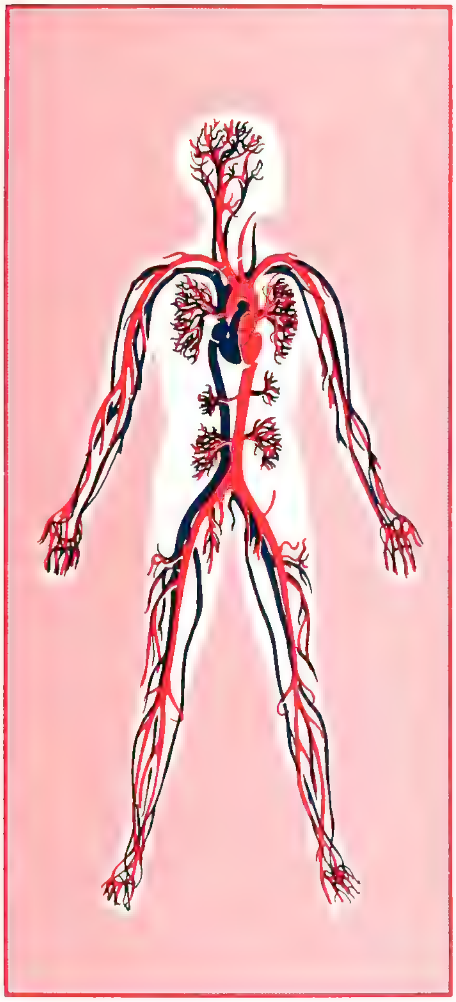
The most effective program for maintaining or modifying body composition requires careful control of caloric intake and routine expenditure of calories through physical activity. An effective exercise program must consist of regular activity three or four days a week. During each session, the heart should achieve a rate of at least 130 to 150 beats per minute for 30 to 60 minutes.

Quite often the most accessible activities are walking and jogging. However, nonweight-bearing exercises such as swimming and biking may be more suitable for overweight or elderly people. Whatever the exercise, the message is clear: to change the composition of the body, particularly by reducing body fat, long-term changes in diet and physical activity are essential.

Donald K. Layman, assistant professor of nutrition; Richard A. Boileau, associate professor of physical education

Diet, Lipoproteins, and Atherosclerosis

Toshiro Nishida



Atherosclerosis is a grave disease that quietly works on its victims for many years or even decades before symptoms appear. As the disease progresses, the arteries or the aorta become narrowed with lesions made up of lipids, cells ladened with lipids, dead cells, and fibrous materials. With time, the lesions may become hardened by deposits of calcium.

In about 90 percent of all coronary heart disease, atherosclerosis is the underlying cause. Victims eventually feel some discomfort or intermittent pain in the chest. The condition can suddenly become lethal as blood clots forming over advanced lesions impede the blood flow or cut it off entirely. A heart attack and often death can follow.

The major lipids that accumulate in artery walls are cholesterol and its esters, which are compounds made of cholesterol and fatty acids. To understand how lipids accumulate in atherosclerotic lesions, it is helpful first to examine the transport processes that carry lipids around the body.

Lipid transport. Because of their insolubility in plasma, lipids circulate in combination with proteins. These lipid-protein combinations are called lipoproteins. They are spherical particles having a core of triglycerides and cholesterol esters, and a surface coat of proteins and phospholipids (Fig. 1). The protein components of lipoproteins are called apoproteins. The surface coat of lipoproteins also contains free cholesterol molecules, which are sandwiched between phospholipid molecules.

Plasma contains four main classes of lipoproteins, which are listed here in the order of decreasing size and increasing density:

- Chylomicrons — produced in the intestine
- Very low density lipoproteins (VLDL) — formed primarily in the liver
- Low density lipoproteins (LDL) — produced from VLDL
- High density lipoproteins (HDL) — secreted by the liver and intestine in precursor form

The differences in density between each major lipoprotein class are mainly due to varying proportions of relatively heavy protein and relatively light lipids (Table 1).

Chylomicrons carry triglycerides derived from the diet. VLDL carries triglycerides synthesized by the liver from carbohydrate and circulating fatty acids. The triglycerides of both chylomicrons and VLDL, after being transported to adipose (fat) tissue, heart, muscle, and other tissues, are hydrolyzed (split) by an enzyme called lipoprotein lipase, located on the blood capillaries at the tissue site. The fatty acids that are thus released are taken up by these tissues and are used as an energy source and as building materials for complex lipids. Any excess fatty acids are stored, primarily in adipose tissues, in the form of triglycerides. The continual removal of the triglyceride constituent from the core makes chylomicrons and VLDL progressively smaller. The resulting chylomicron remnants are disposed of principally by the liver (Fig. 2).

VLDL has a different fate. The removal of most of its triglycerides results in the formation of low density lipoprotein (LDL) (Fig. 2). This lipoprotein contains the highest levels of cholesterol and its esters (Table 1) and is transported to many tissues. Upon reaching the tissue site, specific receptors present on the plasma membranes of the cells recognize, take up, and degrade the LDL particles. The cholesterol component of LDL is primarily used as a structural element of cell membranes.

LDL and atherosclerosis. The onset of atherosclerosis can best be explained by the infiltration theory. Normally, the gaps between the endothelial cells that line the arteries are too small to allow the free passage of LDL. Fluids surrounding smooth muscle and other cells of the arteries therefore usually contain low levels of LDL, which can easily be cleared away. But when cell linings are injured, for example by high blood pressure, LDL can then easily infiltrate, and the concentrations can suddenly increase at the injured sites.

By a sequence of reactions, the injury appears to stimulate smooth muscle cells or other cells in the inner layer of the artery. The stimulated cells then multiply rapidly. Acting as a defense mechanism, the proliferating

*Table 1 — **Four Main Classes of Plasma Lipoproteins in Humans***

Characteristics	**Chylomicron**	**VLDL**[a]	**LDL**[a]	**HDL**[a]
Diameter, Å[b]	1,000-5,000	300-700	190-240	70-100
Density, g/cm^3	0.93	0.95-0.98	1.02-1.04	1.09-1.14
Concentration, mg/100 ml				
Male	12	130	440	300
Female	13	120	390	440
Protein content, percent	2	8	20	50
Lipid content, percent	98	92	80	50
Lipid composition, percent				
Cholesterol esters	3	14	48	35
Free cholesterol	1	8	10	6
Triglycerides	88	58	14	5
Phospholipids	8	20	28	54

[a] VLDL = very low density lipoprotein, LDL = low density lipoprotein, HDL = high density lipoprotein
[b] Å = angstrom An angstrom is equal to one ten-billionth of a meter

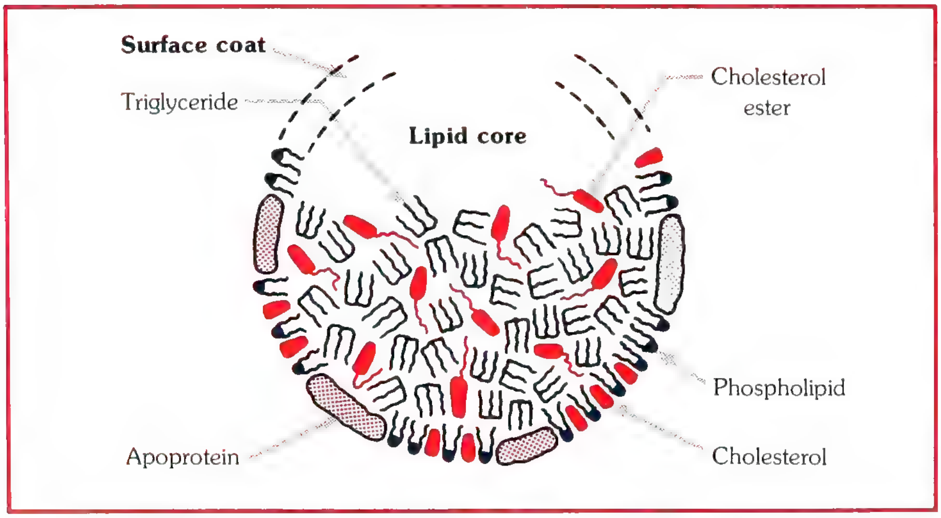


Fig. 1. Structure of lipoproteins, illustrated with a cross section of very low density lipoprotein (VLDL).

cells engulf and destroy the accumulated materials that have infiltrated the injured artery.

Because it is easily taken up by these cells, LDL appears to be particularly atherogenic. Its continual uptake eventually leads to an accumulation of cholesterol and its esters in the form of lipid droplets. As the cells degenerate, the debris together with accumulated extracellular lipids form the core of fatty deposits.

In a healing attempt, the cells continue to proliferate over these deposits, producing additional fibrous materials and subsequently increasing the thickness of the lesions. This sequence of events can repeat itself if the cell lining is continually damaged by high blood pressure or other factors and if local concentrations of blood LDL in particular remain high.

HDL formation. The precursor of high density lipoprotein (HDL) secreted by the liver and intestine is shaped like a disk. The particles become spherical by the enzymatic reaction of lecithin-cholesterol acyltransferase, which produces cholesterol esters and a substance known as lysolecithin. Because of its affinity for water, lysolecithin is removed from the particles. The water-hating cholesterol esters, on the contrary, penetrate the interior of discoidal HDL in an attempt to escape from the aqueous environment. In this way HDL gradu-

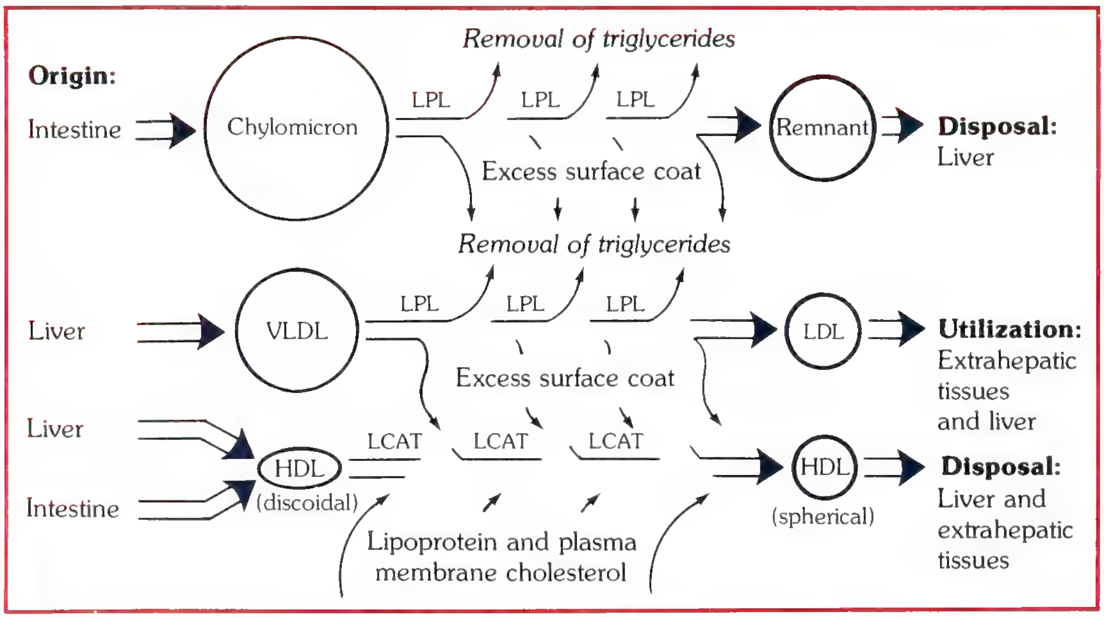


Fig. 2 Schematic representation of the changes in size or shape of various lipoprotein particles during lipid transport processes. LPL = lipoprotein lipase; LCAT = lecithin-cholesterol acyltransferase.

ally becomes spherical (Fig. 2). A portion of the cholesterol esters produced by the enzymatic reaction is transferred from HDL to VLDL and LDL.

The surface coats of the chylomicron and VLDL also become a part of HDL particles. As the triglycerides are removed from the particles, the lipoproteins shrink, resulting in the protrusion of excess surface coat. Gradually most of the excess coat is transferred to HDL and is used by the enzyme lecithin-cholesterol acyltransferase. If HDL does not remove the surface coat materials, lipoprotein lipase will be hindered in its access to the triglycerides in the chylomicron and VLDL particles. Therefore, as scavengers of the excess surface coat, HDL allows the effective hydrolysis and utilization of chylomicron and VLDL triglycerides.

Because of the importance of lecithin-cholesterol acyltransferase in the metabolism of HDL, we have purified the enzyme and clarified a number of its properties. Currently we are studying the interrelationship between the enzyme and lipoprotein metabolism in mammalian systems.

Antiatherogenic effects of HDL. The incidence of atherosclerosis is inversely related to HDL levels: the higher the HDL concentration, the lower is the susceptibility to cardiovascular disease. For the first ten to fifteen years of life, men and women have similar concentrations of HDL. With adolescence, however, HDL levels in men decline 20 to 25 percent, but remain relatively constant in women. The lower incidence of heart disease in women may in part be related to higher concentrations of HDL.

Obesity, uncontrolled diabetes, cigarette smoking, and hypertriglyceridemia (a condition in which excessively high concentrations of triglycerides are present in blood) are all associated with reduced concentrations of HDL and an increased incidence of atherosclerosis. Regular exercise that is moderate to vigorous is often linked with increased HDL levels, as is moderate daily consumption of alcohol.

HDL may help prevent atherosclerosis by removing cholesterol from peripheral tissues, including the arteries and the aorta; the exact mechanism is unknown at present. Being relatively small, HDL particles can easily pass through gaps between the cells that line capillaries and large arteries. Since HDL is not recognized by receptors on the plasma membrane of smooth muscle cells and other cells in the arteries, these cells do not take up much HDL. When it collides with the cell membranes, cholesterol is transferred to HDL. The enzyme lecithin-cholesterol acyltransferase may aid in this transfer. As cholesterol is converted to its esters by the enzyme, part of the HDL surface becomes vacant, thus allowing more cholesterol to be transferred from peripheral tissues to the lipoprotein surface. This cholesterol is ultimately carried to the liver for disposal. The transfer mechanism may be important in preventing or at least slowing down the development of atherosclerotic lesions.

Diet. No single diet can provide a universal solution to atherosclerosis. In general, though, raising HDL and lowering LDL levels seems desirable. The HDL level tends to rise when obese people lose weight by restricting their caloric intake. On the other hand, the HDL level is reduced when the VLDL level goes up with the excessive intake of carbohydrates.

A strongly advocated though controversial preventative measure is a diet high in polyunsaturated fat and low in cholesterol. Such a diet appears to reduce the LDL concentration in people with high LDL levels. However, this diet is not necessarily beneficial for people with elevated levels of VLDL, which is the precursor of atherogenic LDL. VLDL levels can be lowered by restricting carbohydrate or fat intake or by losing weight.

Although the incidence of atherosclerosis in laboratory animals has been increased with a diet high in cholesterol, the proportion was extraordinarily large compared with that consumed by the average human adult. Keep in mind that cholesterol is an essential structural component of cell membranes. It is a major component of the myelin sheath, which insulates nerve fibers. Some cholesterol is also used for the production of steroid hormones and bile salts.

In adults, roughly one gram of cholesterol is excreted per day, primarily as fecal bile salts and sterols. The cholesterol lost is replaced by its synthesis in the body and by uptake from the diet. Cholesterol absorption in humans is relatively inefficient: only 30 to 50 percent is absorbed directly from the food consumed. In healthy adults, when greater amounts are absorbed from dietary sources, the body — mainly the liver — compensates by synthesizing less cholesterol. Therefore, the mean daily intake of 0.5 gram, which is approximately the amount of cholesterol in two eggs, should not constitute a risk. Excessive amounts should certainly be avoided, since individuals vary considerably in their ability to absorb and excrete cholesterol.

At present we have no convincing clinical evidence that lowering LDL or plasma cholesterol levels by dietary or other means can completely protect us against atherosclerosis or prevent coronary heart disease. Nor do we have any convenient methods for assessing the slow, silent progress of atherosclerosis.

Besides high plasma cholesterol or LDL levels, many other risk factors are associated with the disease. Even people having low serum cholesterol or LDL levels may be susceptible to atherosclerosis if the linings of coronary arteries are damaged by high blood pressure or other problems that result in the increased infiltration of LDL. However, the severity or progress of atherosclerosis may be lessened by decreasing the LDL and increasing the HDL levels. Regression of the lesions may accelerate in people with higher HDL and lower LDL levels if injured cell linings are repaired.

To attain beneficial lipoprotein concentrations, people should avoid consuming excessive amounts of cholesterol, fats, and carbohydrates. It is important to obtain a well balanced diet, reduce cigarette smoking, and control blood pressure. By exercising routinely and not overeating, people can substantially reduce the risk of coronary heart disease.

Toshiro Nishida, professor of food science

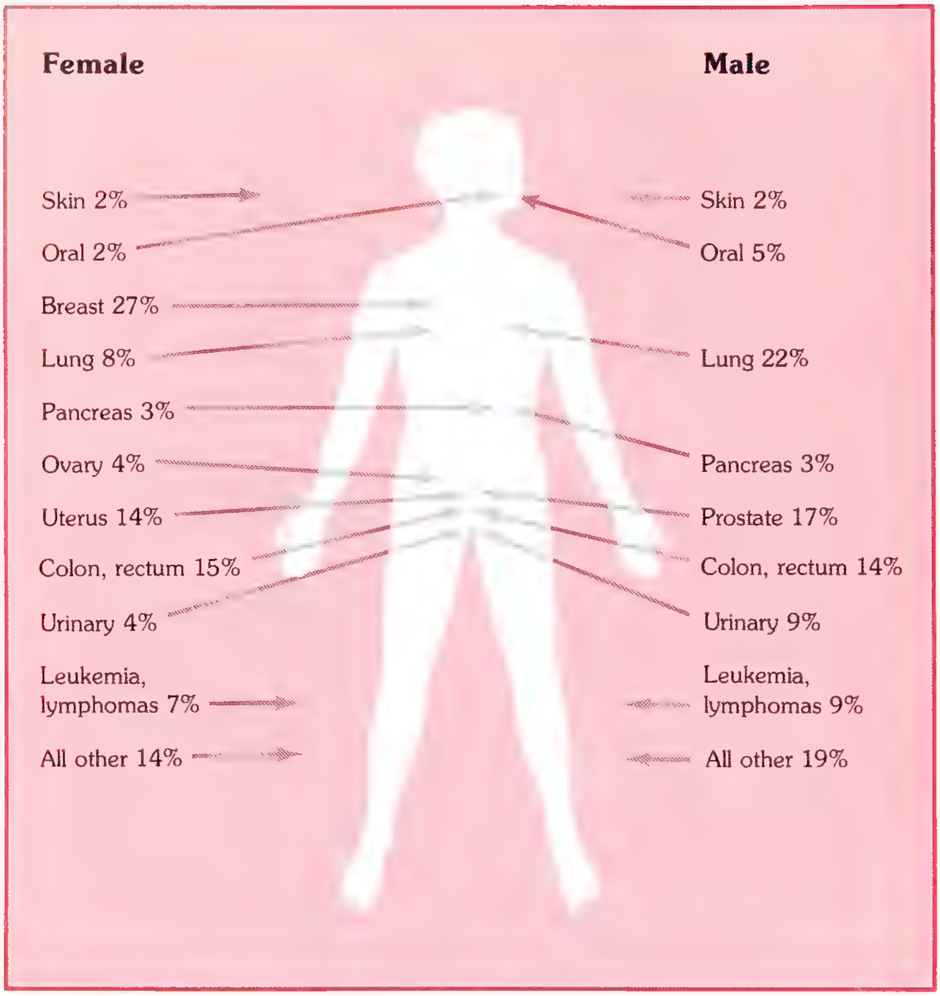


Fig. 1. Estimated cancer incidence for 1980 by site and sex, excluding non-melanoma skin cancer and carcinoma in situ. Source of data: American Cancer Society.

Diacancer

Willard J. Visek and John A. Milner

In the United States, 80 to 90 percent of malignant and benign cancers in humans stem from the environment. Only about 10 percent can be ascribed to heredity or viruses, according to recent estimates. Environment encompasses the air we breathe, agricultural practices, our social and cultural habits, the physical and chemical attributes of our surroundings, and diet, which occupies an important place in this list.

Contrary to a popular misconception, the chemicals arising out of modern technology have not been shown to be the primary environmental cause of cancer. It is certainly true, as the public press reports, that some food additives, pesticides, and industrial chemicals have carcinogenic properties in laboratory animals. But current evidence reveals that relatively few cancers in humans can be reliably traced to chemical contamination.

Diet, on the other hand, is linked to an estimated 60 percent of the cancers in women and more than 40 percent in men. Although these associations have been challenged as incidental, studies in experimental animals show that diet can increase or decrease the number of cancers. Such evidence has stimulated much research and concern, because similar associations in humans ultimately led to identifying cigarette smoking as a major cause of lung cancer.

Our diet with its supply of essential nutrients can alter cancer risk in many ways. The foods we eat may contain agents that cause or assist the cancer process. Cancerous agents such as aflatoxins may be naturally occurring. Intentional or unintentional additives, substances produced during food processing, or those produced by gastrointestinal bacteria during digestion may modify our susceptibility to cancer. Metabolic processes within the liver or other tissues can be changed by the diet, thereby modifying the risk of cancer. Also, the quantity of essential nutrients can modify our susceptibility. In animals, for example, the incidence of cancer can be increased by deficiencies of some vitamins and minerals and decreased by reducing fat and caloric intake.

Epidemiology. Statistics show that 100 kinds of cancers are found in humans (Fig. 1). The most common are cancer of the lung, large intestine, breast, pancreas, prostate, stomach, and blood (leukemia). These seven account for 60 percent of all deaths due to cancer. Except for lung cancer and leukemia, the other five are strongly associated with diet and life-style rather than with environmental contamination.

This point can be illustrated by comparing incidences of particular cancers, and then doing a follow-up to

see what happens to the progeny of people who migrate. Such a comparison reveals that children of immigrants begin to show patterns characteristic of their country of residence, not of their country of ancestral origin.

Complete changes in life-style take about two generations and run parallel to changes in cancer incidence. This finding is true of Japanese migrating to Hawaii or California and of Israeli Jews or Polish citizens migrating to other countries.

Nonmigrating populations living within the United States also demonstrate the importance of life-style, including diet. Thousands of Seventh Day Adventists who live in Los Angeles abstain from alcohol and tobacco. About half of the members eat a lacto-ovo vegetarian diet, and many avoid coffee, hot condiments, and spices. Like the Japanese in Japan, these Seventh Day Adventists live in an air-polluted environment. Yet despite the air quality, their mortality rates from cancer in organs unrelated to smoking and alcohol use are 30 to 50 percent lower than in the general population.

The large Mormon population of Utah provides another example. Mormons have a life-style similar to that of the Seventh Day Adventists, but do not restrict their consumption of meat or other animal products. They too have a lower incidence of cancer and other diseases. Some epidemiologists attribute the similarities between the two groups to common factors of life-style, with a greater than average intake of some dietary constituents such as fiber.

Throughout the world, a high incidence of cancer is correlated with high fat intakes. Results of these correlations can be simply stated: increased calories plus decreased fiber and other essential nutrients equals greater cancer incidence.

Experimental studies. Humans and most animals require about 46 nutrients, including minerals, vitamins, amino acids from proteins, and fatty acids from fat. Under normal circumstances, each nutrient is eaten with others. The influence of individual nutrients may be modified by their interactions.

Caloric intake is one dietary variable that is consistently associated with differences in cancer incidence. Correlations of obesity and cancer of all types in humans have suggested that about a 15-percent increase in tumor incidence is associated with being 20 percent overweight.

Animals given extra calories, whether from protein, fat, or carbohydrate, often have more tumors than their counterparts receiving restricted intakes. Increasing consumption of the calorie-producing components of the diet correlates almost linearly with cancer mortality rates.

As studies at the University of Illinois reveal, laboratory rats fed 40 to 42 percent of their calories as fat develop more chemically induced breast cancers than their counterparts fed only 10 to 20 percent of their calories as fat. The higher percentage of calories from fat is characteristic of the human population in this country.

These studies and those of researchers elsewhere also show a higher incidence of cancer if unsaturated fat such as corn oil is used rather than saturated fat from animal sources. Widely studied as a single variable, fat also interacts with protein to alter tumor development, according to our findings. Furthermore, including natural or synthetic antioxidants in the diet has inhibited cancer incidence in animals.

High intakes of fiber, a constituent of foods from plants, are correlated with a low incidence of cancer, particularly in the gastrointestinal tract of humans. Although not essential for survival, fiber appears to be important in reducing cancer and other diseases.

Vitamins have varying effects on tumor formation. Deficiencies of some vitamins tend to enhance while others tend to suppress tumor development. Excesses may likewise promote or suppress tumor development, depending on the vitamin.

The supply of vitamin A, for example, modifies cancer incidence in animals. Vitamin A is a fat-soluble vitamin that is essential for maintaining the linings and coverings of our organs and body cavities. Since deficiencies among humans are common, the unknown influence of vitamin A in human cancers should be studied.

Vitamin C supplementation in animals has been shown to reduce the formation of some potentially carcinogenic nitrosamines. But in humans the possible benefit of supplemental vitamin C above daily requirements remains an area of controversy.

Some trace elements such as selenium may influence cancer development. The risk of cancer appears to be high among individuals in the United States and other countries where selenium content of the diet is low. Studies conducted at the University of Illinois and elsewhere show that selenium can inhibit experimental cancers induced by various chemicals or viruses. In recent studies, Milner found that selenium also inhibits the growth of transplantable tumors in animals, suggesting that this trace element may be of therapeutic as well as preventative value.

Rates for the same type of cancer range from very low to very high among countries (Fig. 2). This fact clearly indicates that cancer need not be an inevitable consequence of living past the sixth decade, which is when most cancers are diagnosed. If an imaginary popula-

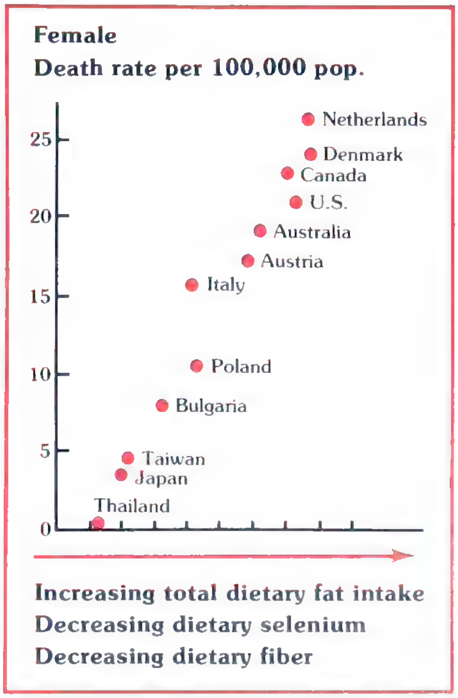


Fig. 2. Age-adjusted mortality rate from breast cancer in relation to dietary fat, selenium, and fiber intake. Composite data from: *Cancer*, Vol. 43, No. 5, May 1979; *Nutrition and Cancer*, M. Winick, ed. New York: Wiley & Sons, 1976.

tion had the lowest recorded rate for each kind of cancer, that country would enjoy a cancer incidence of about one-tenth that in most western countries. Under such circumstances, the United States would have had about 75,000 instead of 750,000 new cases of cancer in 1980. Similar numbers for Illinois would have been 4,100 instead of 41,000.

It is therefore crucial to determine if the differences in cancer incidence among populations are due to potentially alterable environmental factors. Since diet appears to be such an important variable, we need to understand its influence and how it changes the expression of genetic characteristics that are unalterable.

Despite arguments that epidemiological studies cannot establish cause and effect, they have in fact been the basis for finding causes of important diseases in the past. Some of the experiments have been spin-offs from mass migrations, changing national characteristics, or persecutions. These unplanned events should not be ignored, for they can give us valuable information. The validity of associations of diet and cancer revealed by such studies has been striking when carefully tested in animals.

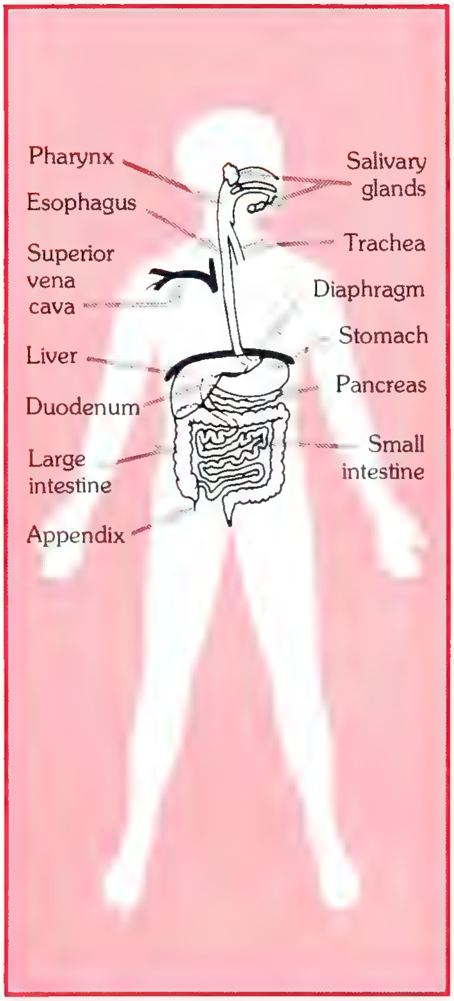
It is imperative that research be continued and the results translated into meaningful dietary practices. Excesses or deficiencies of nutrients throughout life may increase the risk of cancer and cardiovascular disease, which together are responsible for more than two-thirds of the deaths in the United States. As new information develops, we are finding that the overzealous or ill-advised consumption of certain nutrients or foods in order to prevent a particular disease may actually increase the risk of other diseases, including cancer.

Even with a vast accumulation of new knowledge, qualified nutrition experts continue to teach that it is best to eat a varied and balanced diet that maintains weight within a reasonable range. Unspectacular as that recommendation may seem, it continues to be sound advice.

Willard J. Visek, professor of nutrition and metabolism; John A. Milner, associate professor of food science

Nutritional Support in Hospitals

Melanie Shuran, Nancy White, Mark David, and Ralph A. Nelson



Hospitals are not noted for serving home-cooked meals, but patients, perhaps more so than healthy people, need a well balanced, nourishing diet. With proper nutritional support, patients stand a better chance of fighting off disease. In some cases, they may even have fewer side reactions to drugs and may be able to return to work sooner than anticipated.

Malnutrition may become a serious problem for people suffering from diabetes, some intestinal diseases, alcoholism, cancer, and certain other diseases. The elderly can also be affected. To complicate matters, many hospitals withhold meals during diagnostic tests and may fail to record information about a patient's nutritional status. Inadequate nutrition can slow down recovery from illness, delay wound healing, decrease resistance to infection, and increase the risk of post-surgical complications.

A team approach is needed to determine how disease processes have affected a patient's nutritional status and to prescribe and carry out the appropriate nutritional support. In 1976 the Nutritional Support Service at Carle Foundation Hospital in Urbana, Illinois, was organized to meet this urgent need. Currently the team is composed of surgeons, internists, oncologists, nutritionists, nurses, and pharmacists.

Protocols, or plans of treatment, must be set up to monitor and care for patients receiving support. Nutritional assessment data are placed in the patient's chart, along with the team's recommendations for the type of nutritional support and the therapeutic goals. Assessment and treatment entail a series of clinical steps.


Authors Shuran, David, and White review the chart of a Carle Hospital patient who is receiving nutrients through a catheter inserted into the superior vena cava (below right shoulder). Nutrient intake is adjusted as the patient's condition changes.

Step 1. The team first identifies patients requiring nutritional support. People who are malnourished or are at risk of becoming so include those who

- are grossly underweight
- are grossly overweight
- have recently lost 10 percent or more of their usual body weight
- are alcoholics
- have eaten nothing for more than ten days while receiving intravenous solutions of glucose and water or saline
- are losing nutrients because of poor absorption
- have increased metabolic needs because of burns or infection
- have had drug-nutrient interactions

Drugs themselves can produce side effects such as loss of appetite (anorexia), nausea, diarrhea, and changes in absorption, metabolism, and excretion. Conversely, malnutrition is apt to alter the body's reaction to drugs. Some possible changes may occur in drug distribution, excretion, absorption, and metabolism.

Malnutrition can also affect protein binding and toxicity of drugs. For example, digoxin, a drug that is highly protein bound, can become toxic when there is too little protein in the blood (hypoalbuminemia). The effect of fluid, electrolyte, and acid-base balance can be altered by diuretics, corticosteroids, and antibiotics, as well as many other drugs. Therefore, the dose and frequency of administration may have to be adjusted for a malnourished patient.

A deficiency of some nutrients may be caused by the long-term use of drugs such as antacids, steroids, anticonvulsants, salicylates, chelating agents, and laxatives. Monitoring the patient and dealing with the history and current use of medications are important in the overall support of the nutritionally compromised patient.

Step 2. Nutritional assessment is the next step in treating a malnourished patient or one at high risk of developing a deficiency. We draw upon several sources of information to determine the status of different parts and functions of the body.

The assessment begins with a dietary and clinical history, which may provide clues to any underlying malnutrition. Recent weight gain or loss, chronic nausea, vomiting, and diarrhea, recent surgery, chronic illness, and so forth can point to the likelihood that the patient is malnourished.

During the physical examination, we search carefully for signs of nutritional depletion. These signs include evidence of fat and muscle wasting, diseases of the skin, changes in skin turgor, peripheral edema, and enlargement of the liver. With data from the history and physical exam, the existence of malnutrition can often be determined or strongly suspected. Confirmation and quantification are obtained through anthropometric measurements and laboratory analyses.

From four skinfold measurements — triceps, biceps, subscapular, and suprailiac — the percentage and weight of body fat are calculated. Lean body mass is obtained by subtracting body fat from actual body weight. These values are then compared with the ideal body composition for a person of the same sex and age group. Any excess or deficit of fat and lean body mass can thus be determined.

The status of muscle is also assessed using the mid-arm muscle circumference and the creatinine-height index. The excretion of creatinine, a substance formed by muscle, is compared with the ideal excretion for someone of the same height and sex.

We also assess the status of protein metabolism, using measurements of serum albumin, serum transferrin, total lymphocyte count, and other tests. Immunocompetence is determined by recall skin tests. To be considered immunocompetent a patient must have a strong, positive reaction to at least one of the antigens used. If indicated, estimates of nitrogen losses can be made to help us judge the adequacy of protein intake.

Step 3. Kilocalorie and protein requirements are then determined for the patient. The levels of kilocalories are derived from the Harris-Benedict

equations, which estimate the basal or resting energy expenditure for the patient's age, sex, height, and ideal weight. From the estimated expenditure, we calculate the requirements for oral maintenance, as well as the requirements to nourish body tissues through oral or parenteral routes. The amount of protein needed is usually 1.4 grams per kilogram of ideal body weight.

Step 4. After gathering the necessary information, we are ready to work out the details of a nutritional support program for the patient. If he or she is able to eat, support can be as simple as adding between-meal feedings of regular food or special dietary supplements. These feedings can be nutritionally complete or provide a single nutrient such as protein, carbohydrate, fat, or any combination.

Some patients are unable to eat, however, because of head or neck tumors, anorexia, strokes, or other problems. If the patient's gastrointestinal system is intact and functioning, feeding tubes can be used to supply adequate nourishment. The tubes should be soft, durable, and small in circumference.

Inserted through the nose, the tube should be long enough to coil up in the stomach and pass into the duodenum by normal peristalsis. Recent improvements in tube construction have made them safer and less likely to cause rhinitis, pharyngitis, strictures, aspiration pneumonia, or similar complications.

Feedings given through these tubes provide the necessary energy and nutrients, but supplementary water must be added. The use of a pump is recommended to prevent clogging and to ensure a constant rate of delivery. Patients are monitored for signs of diarrhea, dehydration, edema, and glycosuria (sugar in the urine). The Nutritional Support Service changes the rate of delivery or concentration of the feeding as indicated.

If a patient cannot be fed through the enteral (gastrointestinal) route because of recent abdominal surgery, fistulas, and so forth, nutrients must be supplied intravenously. Depending upon the patient's nutritional needs, one of two formulas is used: protein sparing or total parenteral nutrition. Protein-sparing solutions supply estimated protein needs but do not always meet total kilocalorie requirements. Solutions of this type are given to patients who have ample stores of body fat from which energy can be supplied.

In protein-sparing therapy several concentrations of amino acids (3.5 to 5 percent) are available. Added to them are 5 to 10 percent dextrose, vitamins, minerals, and electrolytes. The solution is usually co-infused with a fat emulsion of 10 to 20 percent. Between 1,400 and 2,500 kilocalories can be delivered per day. Because the solution can cause phlebitis, peripheral use must be limited.

The fat emulsion supplies additional kilocalories, prevents or corrects essential fatty acid deficiency, and reduces the risk of phlebitis. No more than 60 percent of the daily kilocalorie intake should be obtained from the emulsion.

In total parenteral nutrition, a central venous catheter is used to administer dextrose (20 to 35 percent), amino acids (3.5 to 5 percent), electrolytes, vitamins, minerals, and fat (10 to 20 percent). This therapy is recommended for patients having moderate to severe nutritional deficits or requiring increased levels of kilocalories because of stress. The daily kilocalorie intake usually ranges from 2,400 to 3,000.

Although a standard form of therapy, this method can cause complications. Therefore, before treatment is started, the catheter must be correctly placed to prevent pneumothorax, arterial puncture, and hemothorax. Septicemia can be avoided by strictly following protocols for dressing changes, catheter insertion, and mixing the solutions in the pharmacy, and by not using the catheter for any other purpose. Metabolic complications such as hyperglycemia, dehydration, acidosis, and abnormal liver function can usually be prevented by adequate monitoring through laboratory tests.

The Nutritional Support Service at Carle Hospital works cooperatively with the College of Medicine at Urbana-Champaign and the Division of Nutritional Sciences. Education in clinical nutrition focuses on support of critically ill patients, and is offered to graduate students and to medical, pharmacy, and medical dietetic students. In a clinical setting, the team has helped graduate students with research in areas such as the metabolic alterations in anorexia nervosa and the use of skinfold measurements in nutritional assessment.

Solutions used in parenteral nutrition therapy are prepared under sterile conditions in the Carle Hospital pharmacy.

Although fairly sophisticated, nutritional support programs are still inadequate for some patients. Basic research and application of the findings to clinical medicine are necessary if we are to offer the best form of nutritional support. Among the problems now facing health care personnel are the need for better daily markers of response to nutritional therapy, as well as proper intravenous formulations of all the trace elements considered essential for human beings.

The Nutritional Support Service is fortunate in having a close working relationship with the Division of Nutritional Sciences at the University. The talent and productivity of nutritional scientists help resolve clinical problems so that we can provide improved patient care.

Melanie Shuran, registered dietitian; Nancy White, registered nurse; Mark David, registered pharmacist; Ralph A. Nelson, professor of nutrition and metabolism

How Much Is Too Much?

John A. Milner and Arthur J. Siedler

The general public has been bombarded from many directions with advice about eating. People are told to limit calories, reduce total fat, increase fiber, decrease cholesterol, and restrict salt.

The *Dietary Guidelines for Americans,* issued by the U.S. Department of Agriculture and Health, Education and Welfare, offers some additional advice: eat a variety of foods; maintain ideal weight; avoid too much sugar and sodium; eat foods with adequate starch; and if you drink alcohol, do so in moderation.

But how much is too much fat, cholesterol, sugar, sodium, and alcohol? What is one's ideal weight? And what is enough starch and fiber? All bona fide nutritionists agree that eating a variety of foods will help you avoid getting too little or too much of specific dietary substances. Apart from this advice, however, the *Guidelines* are difficult to relate to personal needs. The terms *too much, adequate,* and *moderation* require individual interpretation. A decision about quantity calls for a judgment based on all the conditions involved.

The *Guidelines* do indicate some important relationships between nutrients. For example, foods that contain starch and fiber are relatively low in calories and saturated fat and are free of cholesterol. Salty foods, on the other hand, are often associated with saturated fats, cholesterol, and a superabundance of calories.

Some nutrients are absolutely necessary to sustain life and promote optimum health. The Recommended Dietary Allowances (RDAs) spell out the amounts needed by practically all healthy people. At least 46 nutrients are essential in the human diet. RDAs are set well above the minimum requirements to ensure that most people will receive adequate levels of nutrients.

Although expressed as daily allowances, the RDAs do not necessarily have to be met every 24 hours. The body can store some nutrients for later use, so slight inadequacies can be tolerated for short periods without apparent ill effects. As a rule of thumb, you should strive to meet the RDA average for each nutrient every five to eight days. Unfortunately, we don't yet know enough about some nutrients to establish the RDA. Provisional recommendations are made in some cases to indicate a safe range of intake.

Matching recommended allowances with the nutrient contents of an almost unlimited combination of foods is virtually impossible without the help of computers. Therefore, to aid consumers, RDAs are often translated into food groups for meal planning or into the U.S. recommended dietary allowances (US RDAs) found on canned or packaged foods.

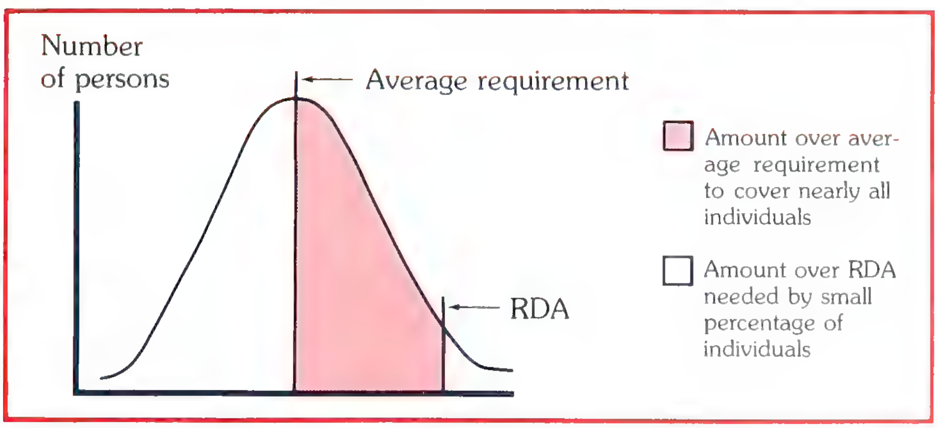
Even the advice to eat a wide variety of foods is not so simple. What is good for the goose may not always be good for the gander. Requirements can vary with heredity, body size, physiological state, activity, total caloric intake, and other factors. To compensate somewhat for these variations, the US RDAs have been set at the highest RDA determined for all ages and both sexes.

Many consumers ask if eating more than the recommended allowance is beneficial. This, too, is a complex question. If the quantity of a nutrient greatly exceeds the dietary requirement, pharmacological problems and toxicity could occur. Excessive amounts of individual nutrients are known to alter the requirement of other nutrients and modify the response to drug therapy. All nutrients can be toxic if consumed in sufficient quantities. Therefore, we discourage the overzealous intake of any nutrient.

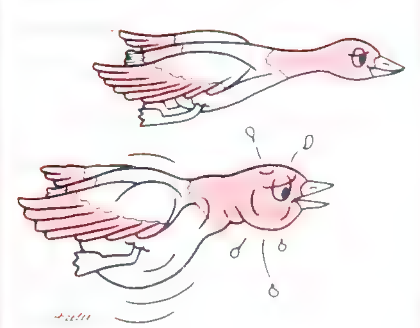
Not everything written about nutrition is golden. While popular books on the subject may be enjoyable late-night reading, many are written by self-proclaimed nutritionists and are loaded with misinformation. If you have any doubts about the validity of nutrition information, contact your Cooperative Extension adviser or a professional who is trained in nutrition.

Copies of the *Dietary Guidelines for Americans* can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

John A. Milner, associate professor of food science; Arthur J. Siedler, professor of food science



People vary in the amount of essential nutrients required. Recommended daily allowances (RDA) are set above the average requirements, as this curve indicates.



I can't understand it. We eat the same things!

In Progress

Geneticist Henry Hadley is attempting to develop broomcorn of a uniform height for easy mechanical harvesting.

The trouble with brooms . . .

"Unaesthetic, inefficient, and unpatriotic" is plant geneticist Henry Hadley's opinion of plastic brooms. By making broomcorn production more economically feasible, Hadley is trying to bring natural brooms back to U.S. agriculture.

Broomcorn is not corn but a sorghum that sports protruding broom fibers on its top. Twenty to thirty plant heads equal one broom.

Mechanical harvesting is a problem because the plants do not produce their heads at the same level. Hadley is trying to develop plants with a uniform height and long-stemmed heads for easy cutting. He is also interested in crossing sweet sorghum and broomcorn; the stalks could be used to make alcohol and the heads to make brooms.

"Broomcorn production could be competitive," Hadley said. Since brush uses solar energy, no fossil fuels are involved as in plastic broom production.

No longer the broomcorn capital, Arcola, Illinois, can still lay claim to having the largest broom shop in the world. Although some broomcorn is grown in Illinois, Colorado, New Mexico, Oklahoma, and Texas, the United States imports 1,000 tons or $1 million of brush a month, mostly from Mexico.

Dusty roads and acid rain

Unpaved roads may be helping to keep rural Illinois clear of a serious acid rain problem. Dust kicked up from unpaved roads and plowed fields is apparently neutralizing the acid rain, according to research conducted by the Department of Forestry and the Illinois State Water Survey. Calcium is a major alkaline component in rainfall, and unpaved roads seem to be one source of this mineral.

Illinois is participating in the National Atmospheric Deposition Program, a network of government agencies and agricultural experiment stations that is monitoring precipitation in the United States to determine what materials are being deposited on the land.

Five sites in the state are being monitored: Bondville, DeKalb, Dixon Springs, Salem, and Carbondale. Rain at these locations is between 4 and 5 on the pH scale, although levels as low as 3.6 have been recorded at Bondville. Precipitation is considered acid if it is below a pH of 5.6.

Tee martoonis — one too many?

Social drinking can be a threat to good nutrition, according to food scientist John Erdman. Two to four alcoholic drinks a day may provide 15 to 20 percent of a person's daily caloric needs, and most of those calories are empty. The remaining 80 percent or so of the calories have to provide 100 percent of the required vitamins, minerals, and protein.

True alcoholics often eat little or nothing. But social drinkers who dilute their nutrients also run the risk of nutrient deficiencies and liver diseases. Erdman and other team members who are studying the effects of various amounts of alcohol on vitamin A metabolism have found a link between alcohol consumption and reduced storage of vitamin A in the liver.

Vitamin A is fairly far down on the list of deficiencies associated with alcoholism, although night blindness and sterility in alcoholics have been connected with vitamin A problems. Supplements are not recommended, however, unless under doctor's orders, because vitamin A can be extremely toxic.

Deficiencies of certain other vitamins are common among alcoholics; for example, 30 percent are low in folic acid and 15 to 20 percent in vitamin B_1 (thiamine). Folic acid deficiency can cause anemia. Thiamine is needed for metabolism of carbohydrates.

Social drinkers run the risk of substituting empty calories for essential nutrients with two to four drinks a day.

Myths about small farms

The trend towards fewer and larger farms has created the mistaken impression that small farms are disappearing from the American scene. Actually, the Midwest has had an increase in the number of small farms, says rural sociologist John van Es.

Small farmers are often thought of as poor and retired — essentially the people left behind in the agricultural transformation. Myths of this sort are basically untrue, according to van Es.

To prove the point, he surveyed 348 small-scale farmers in Peoria and Wayne Counties. Having between 5 and 100 acres, the family-operated farms generate at least $1,000 a year but provide less than half of the family income. Most of the farmers surveyed hold jobs off the farm as skilled workers. The additional income puts most of them in the middle income category.

The farmers in van Es's study are not part of the urban-to-rural shift, which often is associated with professionals who purchase some rural land. Most of the respondents already had a farm background. Surprisingly, these people did not inherit their land. Most of them bought it because of a preference for farm life.

Hens pampered with carbonated water

When the mercury rises, chickens often begin laying soft shelled eggs. Breakage is a multimillion dollar problem in the poultry industry, and hot weather is a major cause. Breeding stock may also be endangered because shell quality affects hatchability.

Chickens cool themselves by panting, which changes the chemistry of their blood. Carbonate is lost during panting, and as a result, less calcium is available for eggshell production.

To get around the problem, graduate research assistant Ted Odom, under the direction of animal scientist Paul Harrison, found that carbonated water fed to chickens sets up a chemical chain reaction that makes more calcium available for eggshells.

Crop production on reclaimed soils

In a five-year study on strip-mine reclamation, agronomist Ivan Jansen found that, in good years, crops yielded well but tended to be susceptible to weather stress because of the poor physical condition of the newly reclaimed soils. During the next five years, he will examine changes in these soils over time.

Jansen and colleagues have been growing corn and soybeans in southern and western Illinois on land reclaimed in different ways to determine the effect on soil productivity. Soybean yields have ranged from 0 to 48 bushels per acre, and corn yields from 0 to 165 bushels without irrigation and from 142 to 191 with irrigation. Yields were lowest in 1980, when severe drought and heat stress led to crop failure at a few sites. Some of the other yield variations were due to reclamation methods.

More than 200,000 acres in Illinois have already been strip mined, and some 5,000 acres are added to this figure each year. Much of the potentially strippable land has productive soils.

"Surface mining and reclamation are costly, and consumers are paying most of those costs," Jansen said. "It's important that we use only effective reclamation methods to give consumers their money's worth."

Before. A mining shovel removes coal from a strip pit at the Peabody River King Mine in southwestern Illinois.

After. A mile from the mine site pictured above, agronomist Ivan Jansen holds a press conference on reclaimed land that was planted to corn.

Treatment for moldy corn

Corn contaminated with aflatoxin can be lethal to animals, and there is reason to believe it is carcinogenic. But an interdisciplinary team of researchers has found that such corn can be treated with ammonia and then used to produce alcohol fuel. Also, the protein-rich residues remaining after treatment are safe enough for livestock feed.

At USDA's Northern Regional Research Laboratory, test-tube studies proved that the ammonia treatment kills aflatoxin. In follow-up studies two University of Illinois scientists, agricultural engineer Errol Rodda and food scientist Marvin Steinberg, have demonstrated that ammonia treatment and alcohol production are feasible on a larger scale.

The treated corn yielded as much alcohol as the control group, and ammonia residues in the feed increased the nutritional value for ruminants. William Buck, professor of veterinary biosciences, has successfully used the ammonia-treated residues in feeding trials.

Aflatoxin is produced by a mold that grows well on corn in the field under moist conditions. More than 100,000 bushels of Illinois corn were contaminated with aflatoxin in 1980.

The mold *Aspergillus flavus* infected more than 60 percent of the kernels on this medium and produced enough aflatoxin to poison livestock.

Update

Analysis of the Agriculture and Food Act of 1981

Robert G. Spitze

On December 22 the President of the United States signed the Agriculture and Food Act of 1981, thus culminating another complex drama of public policymaking. The Act will help shape the working rules for private policy decisions made by farmers, agribusinesses, consumers, exporters, and others.

Many citizens will feel the effects of the Act throughout the 1980s. For example, the nutrition of consumers will be affected by the public research and education provided, the prices of commodities covered under various titles, the availability of the national grains reserve, and the food distribution authorized for millions of low-income recipients. Research has contributed information used in fashioning the Act and can now help interpret it.

Policy Evolution

The 1981 Act is the latest installment in an evolutionary process that reaches back to the eighteenth century, when the Northwest Ordinance first provided for common schools in every township on the frontier. The new Act follows in the course of the price and income policy launched by the Federal Farm Board in 1929. This policy was formed in response to periodic low and variable farm prices and incomes, export and import needs, intermittent surpluses and shortages, and malnourishment in a land of plenty.

Through successive Acts every three to five years, the policy has expanded to include food stamps; food aid abroad; national grains reserve; export embargo protection; research, education, and extension; and aspects of credit, grain marketing, and conservation. The Food and Agriculture Act

of 1977 brought all of these policies together for the first time. The new 1981 Act, the most comprehensive to date, also encompasses phases of rural telephone service, meat import inspection, export promotion, promotion of the flower industry, and plant pest control.

Public policy arises when problems are perceived as too difficult, too extensive, or too persistent for private solution. Some of the problems that are relevant to the 1981 Act are associated with our phenomenal agricultural productivity, increased dependence upon foreign markets usually under government control, and growth of public sensitivity to nutritional deficiencies of the needy, to name but a few. Economic changes exemplifying some of these developments over the past three decades are summarized in the table and in the section that follows.

Farm income has gradually improved with rising productivity, declining farm populations, increased farm size, and expanding markets. However, a substantial drop occurred during the second half of the 1970s, with only 0.1 percent annual real growth. In 1980, real income hit the lowest level since the early 1960s. Total income of farm families has been greatly enhanced by *off-farm income*, often by spouse earnings. Recently this source has been growing at 4.2 percent annually and now in total exceeds that from the farm. During the same period, *total farm debt* rose at a rate of 13 percent annually.

Farm output, of crops for example, has continued increasing at a rapid pace, recently at 3.4 percent annually and sometimes outstripping growth in demand. *Agricultural exports* have risen dramatically. More than a fourth of all farm sales are now slated for export. Yet over these three decades much greater variability has developed in farm income, output, and prices; in consumer food prices; and in exports. Recently, food programs, particularly the *food stamp program*, have grown rapidly even in constant dollars because of rising unemployment. For each 1 percent rise in unemployment, the progams cost an additional three-quarters of a billion dollars. Growth of food programs has created budget concerns and controversy.

U.S. Economic Changes Related to Development of Current Agricultural and Food Policy

Period	Compound annual rates of change (pct.): Income[a] per farm person: Farm	Income[a] per farm person: Nonfarm	Total farm debt[a] per farm person	Output, all crops	Ag. exports as pct. of total marketings, av. for period	Food stamp cost[a], av. for period (million 1972 $)
1950s						
1st half	−3.0	+0.9	+8.3	+0.9	10.6	....
2nd half	−0.3	+5.0	+8.6	+2.5	13.3	....
1960s						
1st half	+4.1	+11.2	+11.9	+1.2	15.2	32
2nd half	+4.3	+7.9	+8.8	+1.1	14.4	262
1970s						
1st half	+7.2	+4.8	+4.0	+2.5	19.8	2,509
2nd half	+0.1	+4.2	+13.1	+3.4	26.4	4,011

[a] In constant dollars

Source of data base: U.S. Department of Agriculture

Provisions of the New Policy

Duration: The four fiscal or crop marketing years from 1982 through 1985.

Food distribution: Food stamps for only one year, with reduced participation and funding ceiling, and with workfare permitted for benefits. Surplus stocks free to the elderly and to child nutrition programs. P.L. 480 aid for donations and credit to needy abroad.

Grain reserves: Farmer-owned, 3-to-5-year wheat and feed grain reserve expanded, with increased discretionary administration and a single release price.

Commodities:

- *Wheat* — Price support minimum at $3.55 per bushel, with reductions possible. Target price minimums for each of the four years at $4.05, $4.30, $4.45, and $4.65. Voluntary set-aside, acreage limitation, paid diversion, and cross-compliance, all at the discretion of the Secretary of Agriculture, may be a condition for benefits.
- *Corn* (other feed grains proportional) — Price support minimum at $2.55 per bushel, with reductions possible. Target price minimums for each of the four years at $2.70, $2.86, $3.03, and $3.18. Other provisions similar to wheat.
- *Soybeans* — Price support minimum at 75 percent of prices for three of last five years, or $5.02 per bushel, with reductions possible.
- *Cotton, rice, peanuts, wool, dairy, sugar* — Price and income supports continued, but with sugar added and dairy and wool supports lowered.
- *Disaster payments* — Generally terminated with the new crop insurance available.
- *Payment limitations* — Maximum payments to any person continued at $50,000.

Exports:

- *Embargoes* — Producers of affected products compensated at 100 percent of parity if embargo placed on only their product.
- *Promotion* — Agricultural Export

Credit Revolving Fund authorized, and export development by the Secretary encouraged.

- *Meat imports* — Must meet domestic species and quality standards.

Conservation: New conservation approaches authorized, conservation of set-aside mandated.

Research and education: Ongoing agricultural research, extension, and education programs authorized.

Analysis and Implications

In the 1981 Act, continuity with past policy outweighs change. The Act provides minimal stability for farm crop prices (and indirectly for livestock prices), for consumer food prices, and for domestic food supplies. Minimal income support is provided for farmers and in turn for agribusinesses. Product availability is secured to some degree for both domestic and foreign consumers, with stress on efficient production.

The Act contains no innovations. It does expand governmental action in several areas, for example by enlarging the reserve, setting minimum price supports for soybeans and sugar, guaranteeing compensation for embargoes, authorizing conservation, promoting exports, and regulating plant pest control. Other governmental actions are reduced, for example by eliminating peanut allotments, phasing out disaster payments, curtailing food programs, reducing target indexing, and allowing increased flexibility. Several provisions warrant further analysis.

Food distribution programs will be scaled down from recent levels. According to research findings, these programs help consumption and nutrition marginally but not in the same proportion as expenditures. The targeted programs, such as those for school children, the elderly, and WIC (pregnant women, infants, and children), have had the greatest effect.

Before curtailment under the current administration, food programs in recent years have annually reached 22 million people through food stamps, 27 million children through school lunches and 4 million with breakfasts, 2 million mothers and children through WIC, 0.6 million elderly, and 0.7 million in child care centers. Direction for food stamps has not yet been set beyond 1982.

Grain reserves were continued with strong support but amidst controversy on the intricacies of release. The compromise calls for a reserve of both feed grains and wheat instead of wheat only; a permissible ceiling of 1.7 billion bushels, up from 300 million bushels; and a single release price applied with much administrative discretion. The policy promises to be a major vehicle for moderating price gyrations. Already the reserve holds more than 1.8 billion bushels and is likely to cost the Treasury at least one billion dollars this year. The program will affect future prices for both farmers and consumers.

Price support minimums on grains, up 6 to 10 percent from previous levels, are low enough to avoid interfering with exports, but will still permit eligible producers the best price during the year. Discretionary authority permits lowering the minimums to $2 for corn and $3 for wheat; the minimums can also be raised. By comparison, dairy supports are lower than previously. Yet, with no production control and with dairy products being somewhat perishable, surplus stocks promise to be problematic. The dairy program will probably be more costly than any other price support program.

Target price minimums, starting at levels near the projected nonland production costs for the previous year, will rise about 6 percent per year. By participating voluntarily in acreage reduction, producers will be assured of this average target return. The return will be realized from the market or from payments equal to the difference between the target level and market prices (or the loan rate if higher). This guarantee could give producers an income margin for survival and help assure a food supply, but could cost the Treasury several billion dollars in times of depressed prices.

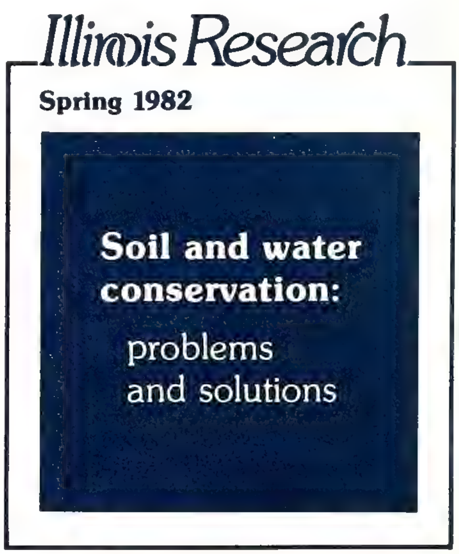
Set-aside and reduced acreage are voluntary means of production control to lower target payments and to help balance production with expected demand. Set-asides for wheat and feed grains have already been announced for 1982. Cross-compliance with other crop programs and paid diversion are also production controls that could be requirements for benefits. Use of these controls would result in the elimination of the lowest prices for both producers and consumers, and possible substantial Treasury costs for inducement payments.

Embargo protection is provided to producers either as loans or payments at the high level of parity (for example, $4.99 currently for corn) following a selective embargo on an agricultural product. With a price tag of billions of dollars, this guarantee should effectively discourage any such embargo.

Conservation of farmland has received increased attention in the 1981 Act. However, while the policy states goals and authorizes additional policy, no funding is specified. Tighter conservation requirements may accompany set-asides.

Research, extension, and education programs are authorized, largely as continuations, and are an integral part of the policy of the 1981 Act "to assure an abundance of food and fiber." To support efficient production, the goals of having an adequate scientific base and an informed citizenry must go hand in hand with the goals for prices, income, trade, and food supply.

Robert G. Spitze, professor of agricultural economics



Illinois Research

College of Agriculture, University of Illinois at Urbana-Champaign, Volume 24, Number 2

The Cover

Magnified fifteen times, the drop of rain pictured on the cover bursts into dozens of droplets as it strikes a solid surface. Raindrops can reach an impact velocity of twenty miles per hour. Upon hitting bare ground, they dislodge soil particles and splash them up to three feet away. Thus the erosion process begins. On sloping land, sheet and rill erosion can cause serious damage to vulnerable soils unless held in check by control practices designed to prevent excessive soil losses.

Photo courtesy of the Naval Research Laboratory.

"At a time unlike any in the past, we must envision the future."

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1982 – Directions – 1992

Soil and Water Conservation: A Concern for All Citizens

The soils of Illinois and the nation were eons in the making. Yet within the next century — a mere moment in earth's long existence — we are threatened with crippling losses of this precious resource. Water quality is directly affected by what happens to the soil.

In Illinois, extensive soil erosion was first seen in the southern part of the state. The problem spread throughout the rest of Illinois when diversified farming declined markedly after World War II. Today, with more than 87 percent of our 24 million acres of farmland planted in corn and soybeans, problems with soil preservation and water quality continue to mount. Although a marvel of technology, modern agriculture is taking a heavy toll on the soil and is jeopardizing the quantity and quality of surface water supplies.

An organized erosion control program led by many dedicated people is under way. Unfortunately, large-scale production practices have outstripped the technology for erosion control. As a result, erosion in many areas of Illinois and the nation exceeds the soil loss tolerance level; soil formation is simply too slow to keep pace with the rate of loss.

Conservation practices may not appear to be cost efficient for most farmers. Without control practices, however, the nation faces a long decline in agricultural production, which inevitably will be felt by all citizens. But public reluctance to fund basic conservation research and implementation is giving way to a growing awareness of the consequences of erosion on the well-being of society.

The Illinois Agricultural Experiment Station will continue to build upon basic and appled research programs in soil conservation and water quality. In addition, we must further define the economics of implementing effective control practices, the consequences of neglect, and the public policy necessary for carrying out control measures.

Our goal must be to sustain agriculture's production capacity not just for this century and this generation but for the centuries and generations that will follow.

Dale H. Vanderholm, assistant director of the Agricultural Experiment Station

Typical splash pattern of raindrops striking a flat surface.
Photos courtesy Naval Research Laboratory.

Mechanisms of Soil Erosion

J. Kent Mitchell

In 1977 alone, the United States lost almost 2.5 billion tons of soil through erosion. Compared with the magnitude of the problem, the basic cause — raindrops — may seem insignificant. Yet falling raindrops strike the ground with surprising, cumulative force. With no vegetative cover or mulch to absorb the impact, rain is especially erosive on cropland left bare between plantings. To understand the problem, let us look at some of the mechanisms of erosion.

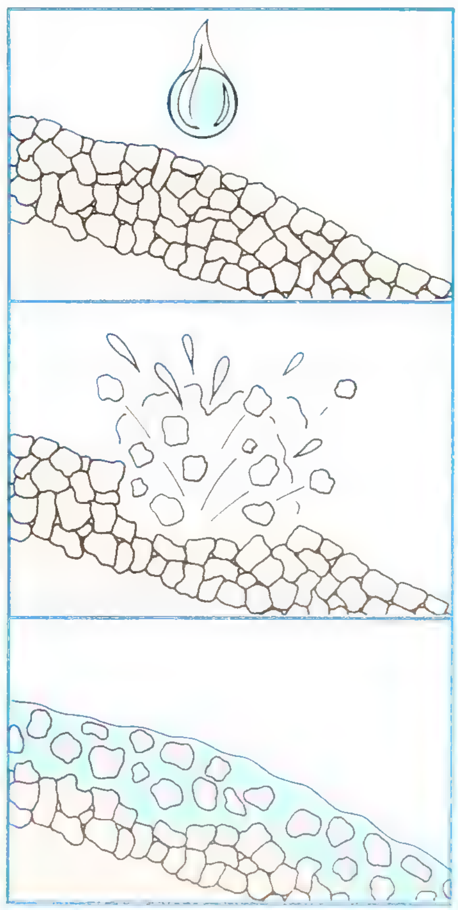
Rainfall. Soil erosion is the detachment of particles from the soil mass and their transport through the watershed system. When it rains, drops up to 6 millimeters in diameter bombard the soil surface at impact velocities of up to 20 miles per hour. In general, the heavier the rainfall, the larger the drops.

The constantly pounding raindrops dislodge soil particles and aggregates and splash them up to 3 feet away. When rain hits vertically on a flat surface, the splash is equal in all directions. On a slope, more of the splash goes downhill than uphill. In a wind-driven rainfall, splash movement depends on slope and wind direction.

A twofold problem often occurs: a rainfall may be too intense to be absorbed, and it may also seal off the surface, thus further reducing infiltration of the water. If water could always filter into the soil, the splashing of particles would be of minor concern. In many cases, however, water collects in low places, eventually overflows, and then begins to travel downhill, carrying soil particles with it.

A raindrop falling on a thin sheet of water detaches soil particles more readily than one falling on dry soil. Splash erosion increases with surface water depth, but only up to a depth about equal to the raindrop diameter. Once the water becomes deeper, the splash effect is reduced.

Water flowing off the soil surface provides the mechanism for transporting particles loosened by rainfall. Although described as sheet flow, this type of flow seldom occurs in an uninterrupted sheet. Usually the water detours around clods, spills out of small depressions, and in general moves with sluggish irregularity. Even so, the water is able to carry soil particles.



Soil particles and aggregates that have been detached by raindrops are transported downslope with runoff.

Sediment deposited by sheet erosion.

Rill erosion on sloping land.

Gully erosion in poorly protected area.

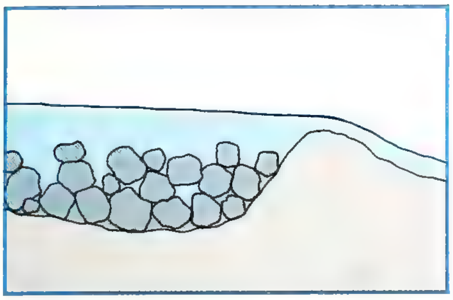
This transport ability is influenced by the energy level of the flow, which in turn is dependent on the depth of flow and slope of the land. Flat areas have little or no runoff; consequently, no transport occurs. Runoff from steeper areas flows at greater velocities and may have considerable transport capability.

Rills and gullies. Under certain conditions, water from sheet flow (inter-rill) areas will run together, forming small rivulets or rills. This type of flow usually occurs on only a small percentage of a field, but because the flow is concentrated, it can cause some erosion. The rills thus created leave small channels that can be obliterated by normal tillage operations. Energy levels of water flowing in rills vary somewhat, depending on the depth of flow and slope of the channel. Long, steep slopes allow rivulets with considerable erosive power to develop.

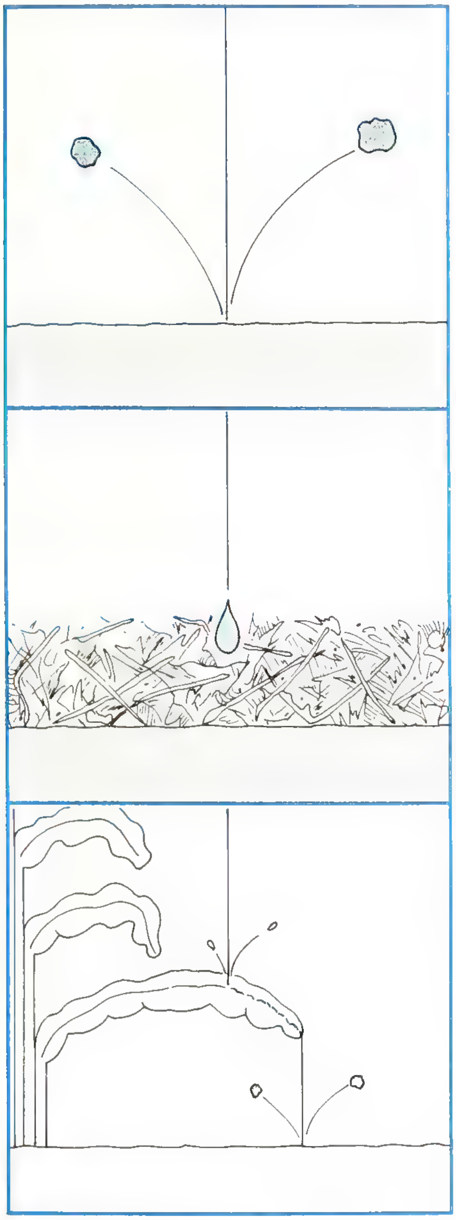
In many soils, rill flow detaches less material than does splash erosion. However, while a rill is forming, raindrops continue to detach soil within shallow rills and from the surrounding soil surface. Rill flow has an exceptional capacity to transport the detached particles. Because the flow is concentrated, much material can be transported within these small channels. A few soils are very susceptible to rill erosion; thus any rill flow that develops can easily detach soil particles or aggregates.

Rills gradually join together to form progressively larger channels, with the flow eventually proceeding to some established streambed. Some of this flow becomes great enough to create gullies, which cannot be obliterated with normal tillage operations. In many areas of the Midwest, gully erosion has done considerable damage to fields by removing valuable topsoil and by dividing fields into very small parcels that are inefficient to farm.

Rills and gullies often progress upstream at a head-cut or overfall (small waterfall). As the pool below the overfall enlarges, the turbulent water undercuts the overfall; eventually the soil sloughs off and is transported downstream. Through similar processes, the banks of streambeds can be undercut and eroded if flow velocities are excessive.



Small natural dam causes ponding of runoff. Sediment drops to the bottom and remains there after the water is released.



With no protective ground cover, raindrops can splash soil particles up to three feet away. Mulch cover cushions the fall of raindrops and hinders or eliminates splash erosion. The leaves of close-growing crops such as soybeans absorb the force of falling raindrops, thus minimizing the splash.

Sediment. Sedimentation from soil or other materials carried by moving water may occur with sheet, rill, gully, and stream flow. Natural or artificial dams are a prime place for runoff to collect. Large particles tend to settle in quiet pools formed at these sites. When the water is slowly released, much of the material is left behind as sediment.

Ponding is apt to occur in small depressions or above contour furrows in inter-rill areas. It may also occur above small debris dams formed from residue in rills and gullies, terrace channels, or reservoirs in large streams. Also, dense vegetation can reduce the flow velocity, thereby allowing soil material to be deposited. Effects of this process are sometimes seen in grassed waterways where the center gradually fills in with sediment.

All three processes of detachment, transport, and sedimentation occur during an erosive rainfall event. The extent is determined by the amount and intensity of rainfall, topography of the land surface, vegetative cover, and character of the soil.

Soils and ground cover. Each type of soil has its own inherent susceptibility to the forces of erosion, in large part because of chemical composition and organic matter content. Although large-grained materials are easily detached by raindrop splash or flowing water, they are not easily transported. On the other hand, fine soils such as clays and fine silts that bond together tightly are not easily detached, but once free they are transported with little difficulty. For this reason, fine materials can be carried considerable distances, whereas larger particles are deposited somewhere along the flow path.

Mulch and vegetative covers play an important role in hindering the erosion process. For example, mulch lying directly on the ground and completely covering the soil surface absorbs the force of a falling raindrop and thus eliminates splash erosion.

Canopy covers will also reduce drop erosion to a great extent. Close-growing crops such as corn and soybeans catch raindrops and keep them from hitting the soil directly. Much of the water runs down the plant stem, although some of it runs off the leaves. Falling on bare soil, these drops cause a small amount of detachment, but since they have not fallen far enough to reach an erosive velocity of any significance, detachment is less than with no canopy cover.

Trees provide less protection for bare soil because of the greater height from which the drops fall. However, forests usually contain protective ground cover in the form of leaf or needle mulch.

Not only do ground covers intercept raindrops and keep them from detaching soil particles, but these covers also prevent soil compaction, which restricts infiltration of water into the soil. With greater infiltration there is less runoff. However, some runoff with transport capacity will occur.

Even when no particles are detached by raindrop splash, the flow itself, forming larger and larger rivulets, can eventually loosen particles. By slowing down the velocity of flowing water, vegetation is helpful in reducing flow erosion. In a highly susceptible soil, some rill erosion may occur beneath the mulch cover, but the flow is impeded and the degree of erosion reduced.

Studies. Many factors, among them rainfall, soil, topography, and vegetative cover, affect the erosion process. Although many of these processes are recognized and understood, scientists do not yet have enough detail for developing physically based mathematical models. Some investigations have advanced more rapidly than others. For example, U.S. Department of Agriculture scientists at Purdue University and at Oxford, Mississippi, have made considerable progress in defining splash detachment and inter-rill transport mechanisms. Work in defining rill flow detachment and transport mechanisms continues, and progress is being made.

Over the last fifty years the sedimentation characteristics of many reservoirs throughout the United States have been described. These investigations have resulted in empirical descriptions of sediment yields from watersheds. Some mathematical descriptions of the deposition of sediment in reservoirs have also been completed. However, the continually changing processes from source area

to watershed outlet still lack mathematical descriptions of the mechanics involved. Several models that are partly theoretical and partly empirical provide descriptions of erosion and sediment yields from agricultural watersheds.

Studies at the University of Illinois are contributing to these descriptions. Near Monticello, Illinois, two small agricultural watersheds with five nested subwatersheds are being continuously monitored for data that will be used to describe the transport process through the watershed flow system. In related work, a raindrop tower with rainfall simulator provides an excellent facility for studying basic splash erosion and inter-rill processes.

At present the Universal Soil Loss Equation (USLE) is the most widely accepted method of estimating soil loss from land surfaces. The equation includes the effects of rainfall erosivity, soil erodibility, slope, slope length, ground cover, and erosion control practices. Although empirical, the USLE provides the best estimates available for these complex phenomena. Using the USLE, conservationists can estimate soil loss from a field and recommend alternative cultural practices for bringing excessive erosion to within tolerable limits.

Many researchers are working on ways to improve estimates of the various parameters in this equation. At the University of Illinois we are studying the effects of five tillage cropping sequences on erosion after soybean cultivation. These studies will provide some immediate answers to help conservationists in planning erosion prevention.

We still need models that describe the erosion process in precise physical terms, but this is a long-range project. We also need to evaluate parameters for methods now used for estimating erosion. Both types of studies must continue concurrently. The new knowledge gained will help researchers develop exact descriptions for clearly defining erosion and sediment transport. The evaluation of parameters for current prediction methods enable conservationists to define causes and suggest cures for erosion problems.

J. Kent Mitchell, associate professor of agricultural engineering

Erosion on Farmlands

Robert A. Pope and Joe B. Fehrenbacher

During the course of a year, Illinois contributes its fair share of eroded soil to the national total. According to estimates by the Illinois Environmental Protection Agency, 40 percent of the state's cropland, or 9.6 million acres, loses an average of 11.7 tons of soil per acre each year. At that rate, one inch of soil is stripped away about every fifteen years.

A popularly held belief among some people is that two bushels of soil are being mined for every bushel of corn produced on this excessively eroded land. The result will be the eventual destruction of the soil. Others point to the fact that crop yields have been increasing since the Dust Bowl years of the 1930s. Modern agricultural technology, according to this competing view, has diminished the importance of topsoil for crop production.

Which view is correct? It all depends on the soil in question.

Topsoil. Most of the nutrients used by crop plants are concentrated in the plow layer, the top 6 to 9 inches of soil. Phosphorus and potassium fertilizers are strongly held there by soil clays and organic matter and consequently do not move deeper into the soil. Topsoil also contains most of the soil organic matter, which stabilizes the structure of the soil and maintains its permeability. Most of the nitrogen needed by nonleguminous plants is contained in the organic matter.

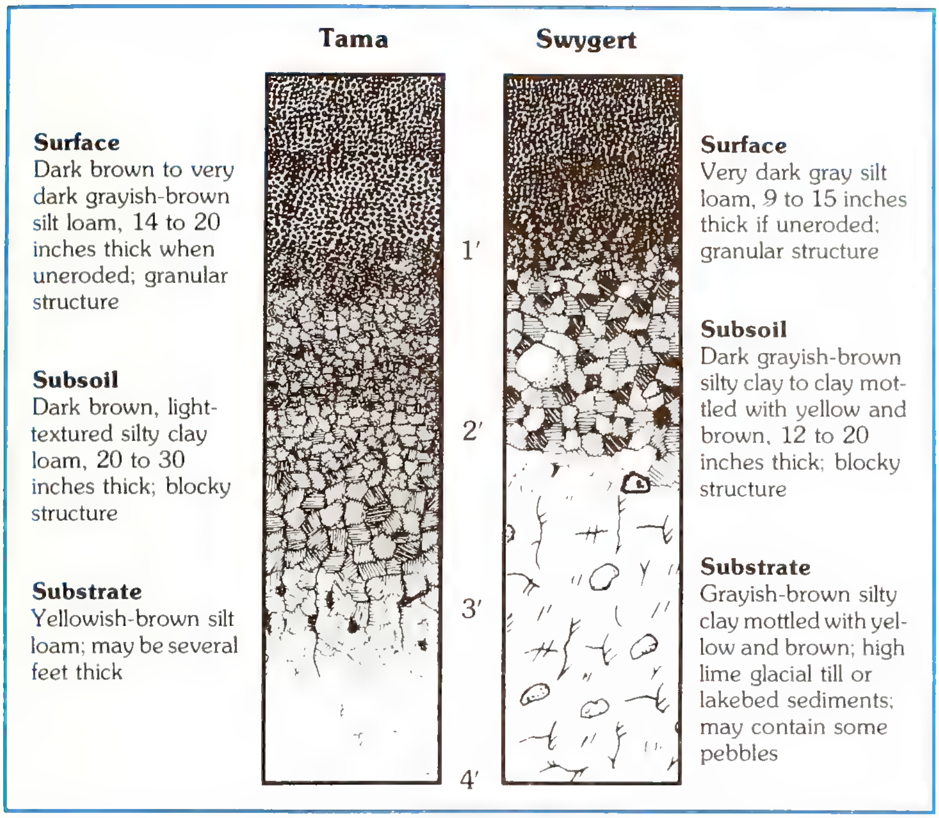
During the 1940s, studies were conducted in Illinois on Tama silt loam, a productive prairie soil subject to excessive erosion. In these studies, a one-inch reduction in topsoil thickness resulted in a yield decline of roughly 1.1 to 1.2 bushels per acre. A somewhat later study conducted in Iowa on a similar soil also revealed a sharp decline in yield as the thickness of the surface soil was decreased. Both studies clearly showed that erosion of topsoil reduced the native productivity of the land.

The Iowa researchers also compared the effects of different rates of nitrogen fertilizer on uneroded and severely eroded soil. With no applied fertilizer, corn yields from the eroded plots were 60 percent lower than yields from the uneroded plots. Nitrogen fertilizer increased the yields from both soils. When nitrogen was applied at adequate rates, maximum corn yields were obtained from both eroded and uneroded sites.

On the highly permeable, thick soil used in the Iowa experiment, technology in the form of nitrogen fertilizer was able to serve as a substitute for topsoil. However, more nitrogen was needed to maximize yields on the severely eroded soil, because a reserve of soil organic nitrogen was not present to supplement the fertilizer.

The Iowa example is extreme because all of the surface soil was stripped from the plots with a bulldozer in one operation to produce the erosion effect. Even in severe cases of eroding fields in clean tilled crops, soil losses occur at a far slower rate. With a loss of ten tons per acre each year, which is twice the soil loss tolerance level for a productive soil like Tama, it would take sixteen years to lose one inch of topsoil. Compared with the extreme conditions in the Iowa study, most eroding fields in Illinois would need much less extra nitrogen fertilizer to maintain high corn yields.

Phosphorus and potassium are also lost when soils erode. Total amounts of these nutrients in an inch of topsoil are very high. Before the



Tama is a thick, productive prairie soil with a permeable subsoil. Swygert soils have a relatively thin layer of surface soil and a subsoil containing a very high percentage of clay.
Source: U.S. Department of Agriculture, Soil Conservation Service.

widespread use of fertilizers, analyses in the early 1920s showed that the plow layer of Tama soil contained 1,080 pounds of phosphorus and 32,800 pounds of potassium. Only a fraction is held in a form that is available to crop plants, however. Loss of available rather than total nutrients is more important when assessing effects on soil productivity.

In Illinois, current recommendations based on soil tests call for phosphorus levels of 50 pounds and potassium levels of 300 pounds per acre to maintain high yields on most soils. Research has shown that about 9 pounds of phosphate and 4 pounds of potash are needed to change the soil tests by one pound per acre.

When additional nutrients are being removed by erosion, a farmer will probably see a decline in the overall test levels if he adds only enough fertilizer to replace the nutrients removed by the crop.

Most physical limitations resulting from erosion can usually be overcome in the short run with careful soil management practices aided by modern planting equipment. In particular, measures must be taken to compensate for the loss of soil organic matter, which stabilizes soil structure, helps promote infiltration of water, and reduces crust formation with related problems during crop emergence.

Subsoil. The foregoing discussion assumes that the topsoil is thick and that the subsoil is permeable, easily penetrated by crop roots, and can hold water efficiently. But as many farmers know, not all of the soils found throughout Illinois have favorable subsoil conditions.

For example, the Swygert soils found in some northeastern parts of the state were formed in a thin layer of silty material over dense glacial till containing a very high percentage of clay. In the late 1940s, yields from this soil were compared with those from the thick-layered Tama with its permeable subsoil. For every inch of topsoil removed, the yield loss for the Swygert was 2.5 times greater than for the Tama. The properties of the subsoil clearly have a direct bearing on the productivity of eroding topsoils.

Subsoils vary considerably in Illinois. Many, especially in areas of thick loess, are favorable for crop root development. Others, composed of dense glacial till, some claypans, fragipans, or sand and gravel, either restrict root development or cannot hold sufficient plant-available water to meet crop needs during short periods of inadequate rainfall. In these cases, the loss of surface soil with its water-holding capacity can cause a permanent decrease in the productivity of a soil.

Unfortunately, all of our data on the relationship between productivity and topsoil thickness in Illinois were developed from a very limited number of soils representing two extremes in subsoil characteristics. At the time of these studies, management practices were very basic; consequently, we can only speculate about the effects of topsoil loss on soil productivity under the much more advanced management inputs in use today.

We urgently need replicated experiments on bench-mark soils under varying levels of management to help us evaluate the effects of soil erosion on productivity. With this information we will be able to make intelligent decisions about the development and application of soil conservation programs. Until then, we can only offer an educated guess about whether a particular soil will eventually be destroyed by erosion or whether, in fact, erosion control even matters with advances in modern agricultural technology.

Robert A. Pope, assistant professor of soils, Extension; Joe B. Fehrenbacher, professor of pedology

Downstream Problems From Sediment

Robert D. Walker

When soils are eroded by rainfall, the sediment must go somewhere. Most of the nearly 160 million tons of sediment produced from Illinois agricultural land each year ends up downslope only a short distance from the site of erosion. But substantial amounts leave the fields and enter the stream system.

In the right place at the right time, sediment can have a beneficial effect. Deposited by water along rivers and streams, it can form rich alluvial soils. Approximately 7 percent, or 2.5 million acres, of Illinois land was developed this way. In the wrong place at the wrong time, however, sediment can be a headache for a great many people.

When the pioneers started tilling Illinois soils, erosion and sedimentation began in earnest and have steadily become worse with the intensification of our cropping system. At the turn of the century, Illinois farmers grew about 10 million acres of row crops, mostly corn. Fewer than 1,000 acres were planted to soybeans in 1914. Since then, the soybean acreage has gradually increased to about 9.5 million acres.

Over the years, the number of beef and dairy herds in Illinois has gradually decreased so that the need for hay crops, generally considered a soil saver, has also decreased. As herds have been sold, land use has shifted to the intense production of row crops.

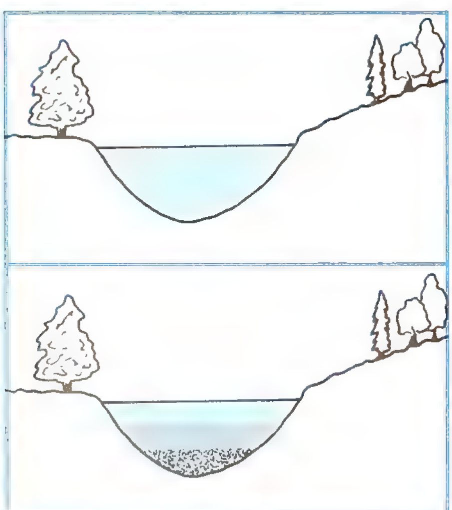
Today, the combination of 11 million acres of corn and 9.5 million acres of soybeans adds up to 20.5 million acres of row crops that are grown on the 23.8 million acres of Illinois cropland. Although a problem after corn, soil erosion is even more severe following soybeans. On sloping land, erosion can be especially troublesome.

But the problem isn't confined to farmland. The sediment that leaves fields often has an adverse effect on the water quality and condition of the state's drainage ditches, lakes, reservoirs, and streams. Many types of problems arise: sediment decreases the storage capacity of lakes and reservoirs, clogs streams and drainage channels, causes deterioration of aquatic habitats, muddies recreational waters, increases water treatment costs, and carries displaced plant nutrients.

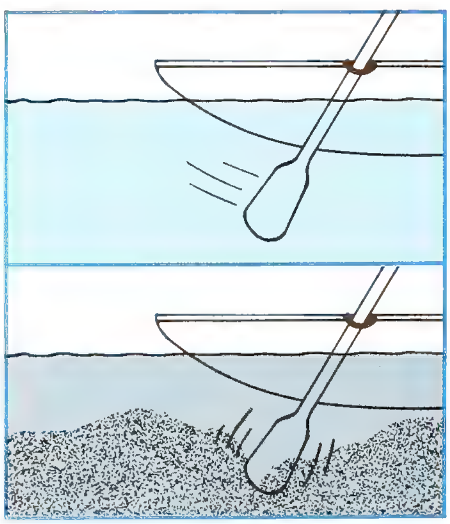
Sediment in drainage ditches. In 1978 the Illinois Environmental Protection Agency (EPA) surveyed county highway superintendents and maintenance engineers for the state highway districts to determine the cost of sediment removal from drainage ditches along roads. Responses came in from 8 of the 9 highway districts and 37 of the 102 counties. The total annual expenditure for only these districts and counties was an estimated $2.97 million for removal of 1.1 million cubic yards of sediment. Had everyone responded to the survey, the figure would have been closer to $6 million, according to an EPA estimate.

Farm drainage ditches along the foothills of the Illinois and Mississippi Rivers are very susceptible to sedimentation. In Brown County, for example, the Hambraugh-Martin watershed had a severe soil erosion problem on steep slopes near bottomland along the Illinois River. When sediment-ladened water rushing off the slopes reached the flat bottomland, the water velocity was slowed and sediment was dropped. Within four or five years the ditches were filled. Through the Hambraugh-Martin watershed project, retaining dams were built near the base of the hills. Now, only clear water leaves the sediment basins, and the drainage ditches remain open.

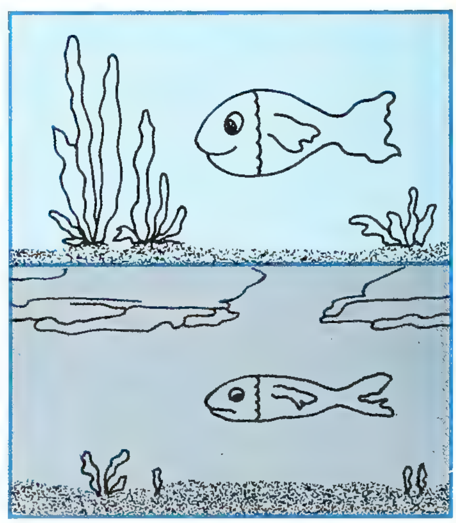
Lake sediment. Bottomland lakes along the Illinois River are becoming casualties of sedimentation, according to studies conducted by the Illinois Natural History Survey.



Sediment is slowly collecting in many lakes, reservoirs, and drainage ditches.



Large portions of some lakes have become too shallow for boating and swimming.



Fish habitats are being altered, and algae proliferate to an undesirable extent.

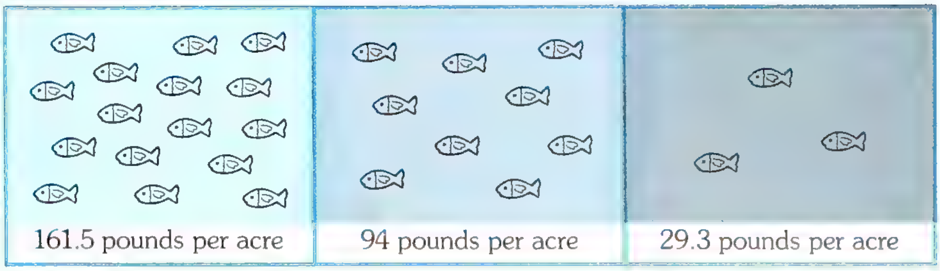
Between 1926 and 1976 Lake Chautauqua, just north of Havana, lost 34.7 percent of its original capacity. The maximum depth of the southern two-thirds of the 3,562 acre lake was only 18 inches by 1976. Sediment has filled the deeper areas much faster than the shallow areas, and the lake is now uniformly shallow. Fish biologists say that the shallowness has led to a severe loss of fish habitats.

Lake Chautauqua is not the only example. A similar story can be told about Lake DuPue (Bureau County), which lost 72.6 percent of its capacity, and Lake Meredosia (Morgan and Cass Counties), which lost 46 percent, from 1903 to 1975. In the summer of 1976 a Natural History Survey crew failed in their attempts to sample other bottomland lakes along the Illinois River. Because of extensive sedimentation, it was impossible to float a canoe on much of the surface area of the lakes.

Lake Paradise in east central Illinois is another prime example of lake sedimentation. Constructed in 1908 for industrial uses, the lake was purchased in 1935 by the city of Mattoon to supplement the city's groundwater supply. Originally the lake had a surface area of 110 acres, but was later enlarged to 220 acres with the installation of a second dam. Over the years, however, sediment filled so much of the lake that it was absolutely dry during the height of the 1951-1955 drought.

According to the Illinois State Water Survey, the problem was created by an estimated 10,000 tons of topsoil leaving the 17 square mile watershed as sediment each year. Understandably, residents living near the lake became quite concerned about the declining value of their once beautiful lakeside property and the loss of a community recreational facility.

The sedimentation problem can be costly in other ways too. Unless dredged, lakes used as reservoirs can jeopardize city water supplies if sedimentation becomes severe. Dredging the estimated 8,263 cubic yards



As turbidity levels rise in ponds, fewer fish are able to live and reproduce in the sediment-filled water. The weight and number of fish tend to decrease as Jackson turbidity units (JTU) increase.

of sediment caught annually in Illinois reservoirs would cost $17.7 million each year if done as needed, according to 1978 estimates made by the Illinois EPA.

Damage to aquatic habitats. Farmers are familiar with the ability of plants to produce organic matter (food) from sunlight, carbon dioxide, plant nutrients, and water. The same process of photosynthesis goes on in lakes and streams, but only in the eutrophic zone, or upper layer, where sunlight can penetrate. When excessive quantities of solids or soil particles are suspended in water, the eutrophic zone can become quite shallow.

Green plants growing in water require nutrients, as do plants growing on land. But with large amounts of fertilizers being washed from fields into streams and lakes, the growth of aquatic plants has become excessive in many Illinois lakes and ponds. Algae, usually the most noticeable plant growth, often become a nuisance to boaters and fishing enthusiasts. At times in late summer, dead and decaying algae can reduce the oxygen content of water to the point where fish die.

Using Jackson Turbidity Units to measure light penetration, H. D. Buck studied twelve Oklahoma fish ponds with a wide range of turbidity levels. The ponds were divided into three classes: clear (less than 25 JTU), intermediate (25 to 100 JTU), and muddy (100 or more JTU). After two growing seasons, the average total weight of fish in clear ponds was 161.5 pounds per acre, in intermediate ponds, 94 pounds, and in muddy ponds, 29.3 pounds.

When turbidity levels are high, sight-feeding fish such as largemouth bass have difficulty finding adequate food. If the turbidity persists, their population will decrease. By changing the habitat and food supply, sediment can also alter the species composition of a body of water. For example, the sunfish family, which includes largemouth bass, bluegill, and crappie, lays eggs in nests constructed in shallow water, preferably on a firm bed. Reproduction of these species declines when firm lake bottoms are covered with soft silt. As sediment fills a lake or pond, populations of desirable game fish decrease and less desirable species such as carp, buffalo, and bullheads increase.

The fish and aquatic life of our lakes and streams are part of a complex food chain that feeds the biotic system of rivers. Failure to maintain the quality of smaller bodies of water will inevitably result in the loss of fishery in the main rivers.

We can compare the relationship between streams and rivers to the leaves of a corn plant. If the leaves feeding the rest of the plant are diseased, the plant will not be healthy and may even die. Similarly, when the aquatic environment is severely disturbed and fish die, the water quality of a particular stream might very well adversely affect the river it flows into and may be hazardous for human uses as well.

Excess plant nutrients. Current evidence indicates that nitrogen and phosphorus, two of the sixteen elements essential for plant growth, are the principal nutrients polluting water. The major sources of nitrogen and phosphorus reaching Illinois water systems are soil, crop residue, decayed organic matter, sewage, livestock waste, fertilizers, and airborne residues

from oil and coal combustion. Even when fertilizers and livestock waste are not applied to the soil, plant nutrients will leak from the system.

Plant nutrients that enter the water system may be dissolved in water or attached to soil particles. Under normal conditions, 90 to 95 percent of the phosphorus reaching the water system from agricultural land will be attached to soil.

Acceleration of the eutrophication process is the major problem created by excessive amounts of nutrients. The problem is more severe in lakes than in steams. Eutrophication in lakes is characterized by an abundance of nutrients, increased plant growth, and depletion of oxygen, leading to early death of the lake.

In its nitrate form, nitrogen in drinking water has been known to cause serious and sometimes fatal poisoning in infants. Nitrates ingested by infants interact with compounds in the bloodstream to interfere with oxygen transport. Methemoglobinemia, the technical name given to this illness, is often called the blue-baby syndrome because infants are very susceptible. About ten public surface water supplies and ten public well water supplies in Illinois currently exceed the public health standard of 10 parts per million nitrate nitrogen during at least part of the year.

The effects of soil erosion are widespread throughout the state. In the wake of erosion come many problems, not the least of which are the effects on our lakes, streams, drainage ditches, and water supply. In one way or another, virtually everyone in the state is affected.

Robert D. Walker, associate professor of natural resources, Extension

The business end of a chisel plow leaves crop residues on the roughened soil surface, thereby helping to reduce erosion.

Contour strip cropping on sloping areas alternates row crops with small grains, forage crops, or grasses.

Grassed waterways, along with conservation tillage practices, provide erosion control on gently sloping land.

Before Erosion Gets Out of Hand

Dale H. Vanderholm

The erosion process is set in motion by raindrops striking bare ground. Sloping land hastens the process. The trick is to cushion the force of falling raindrops and to reduce slope length and steepness. Producers can use a combination of several currently recommended erosion control practices. The choice among them will depend on the local soil, topography, and climate, as well as on farming practices and operator preference.

The degree of erosion is significantly affected by cropping and management decisions about rotations, vegetative cover, fertility levels, tillage practices, crop residues, and the like. Because of the interaction among these and other factors, careful consideration must be given to selecting an effective combination.

For example, crop sequences within a system can be varied. A return to rotations that include one or more years of hay and small grains may be the most economical approach to erosion control in some parts of the state. Residues are also an effective control. They can be left on the surface, incorporated near the surface, or plowed under. When left on the surface, the residues can be chopped or remain unchopped after harvest. Seedbeds can be kept rough to allow surface storage of rain, or they can be left smooth or untilled.

Conservation tillage refers to methods that leave a protective cover of crop residue or that roughen the soil surface; the two strategies can be combined. The residues and the roughness are maintained through planting time into the period of early growth, when erosion damage is most likely to occur.

Conservation tillage protects the soil by increasing water infiltration and surface storage, reducing raindrop splash, and improving the physical condition of the surface layer. This practice also cuts down on labor requirements and fuel costs. In addition, crop residues and a rough surface help control wind erosion. Conservation tillage lends itself to a variety of methods:

Zero till. Seeds are planted without disturbing the soil except in the immediate area of the seed row.

Chisel plow system. Primary tillage is done either in the fall or in the spring with a chisel plow, followed in the spring by secondary tillage with a field cultivator. A protective cover of crop residue is left on the ground.

Disk system. This method is similar to the chisel plow system, but uses a heavy disk instead. Tillage is done in the fall following corn and in the spring following soybeans.

Till plant. The seedbed is prepared by scalping the old crop row and pushing the soil and residue to the inter-row area.

Plow-plant. Moldboard plowing and planting are done in the same operation, or planting can follow soon after plowing.

Wheel track planting. Moldboard plowing is done first, followed by planting in the the wheel track during a separate operation.

Other erosion control practices may be necessary as well. Briefly defined, these practices include:

Contouring: the practice of planting row crops and tilling across the slope or on the contour. Most effective on slopes of 2 to 7 percent, contouring can reduce by 50 percent the erosion that occurs with uphill and downhill farming. To benefit fully from contouring, fields should be relatively free of gullies, and all waterways should be grassed.

Contour strip cropping: the practice of alternating strips of sod with strips of row crops or small grain, all planted on the contour. This practice is more effective than contouring alone. Ranging from 60 to 100 feet, strip widths can be adjusted to fit machinery size.

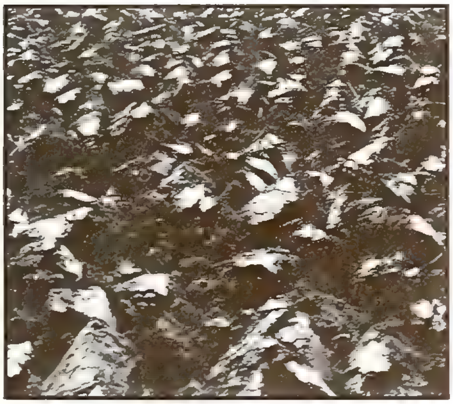
Terracing: a series of across-slope channels, with tillage and planting running parallel to them. Terraces, which control soil erosion by reducing the length of slopes exposed to runoff, are more effective than strip cropping for erosion control.

Waterways: natural or constructed watercourses and outlets that are shaped or graded, then planted with suitable vegetation or lined with an erosion-resistant material. Designed to dispose of runoff without eroding or flooding, waterways serve as outlets for terraces, diversions, or other concentrations of water.

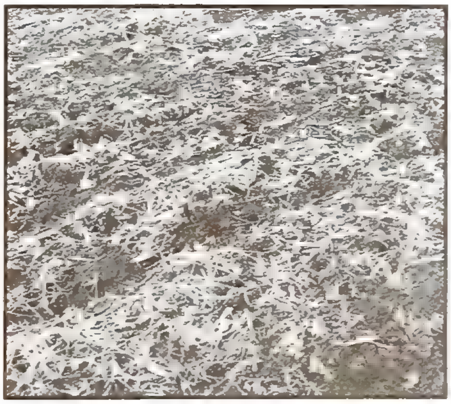
Many other erosion control methods can be helpful, such as the use of seasonal cover crops and grade stabilization structures, land use conversion, and vegetated field borders. Used singly or in combination, all of the methods discussed here can help reduce erosion of cropland areas.

Combating erosion may require substantial changes in overall farm management. Researchers will continue to work on new and improved methods that will be both effective and economical. Meanwhile, the erosion control methods just discussed will be the major ones available in the near future.

Dale H. Vanderholm, associate professor of agricultural engineering



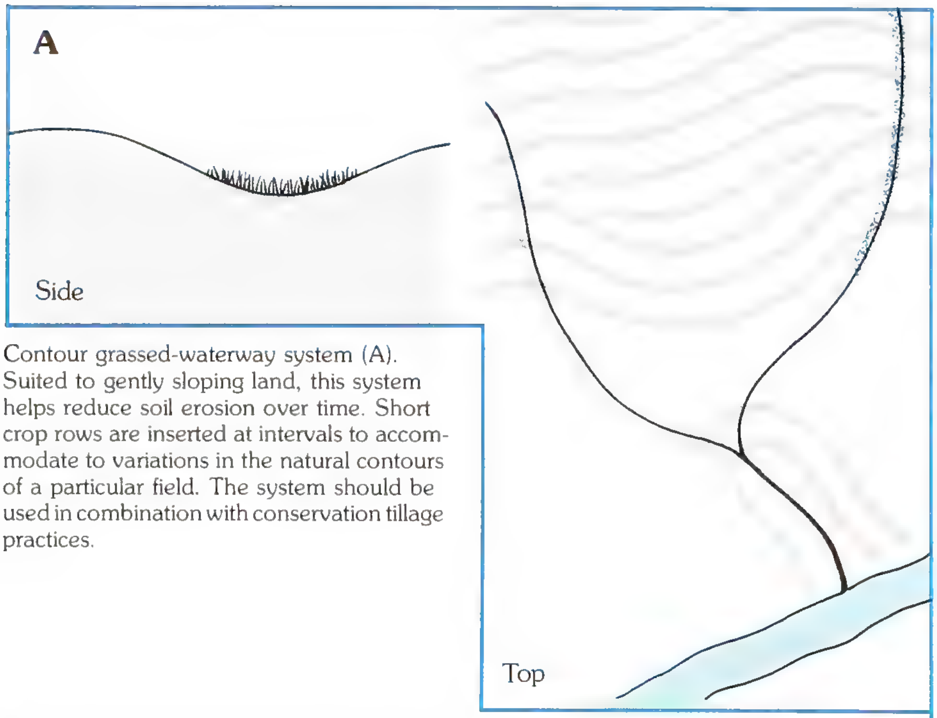
Moldboard plowing, which completely buries residues, leaves the soil exposed to water and wind erosion.



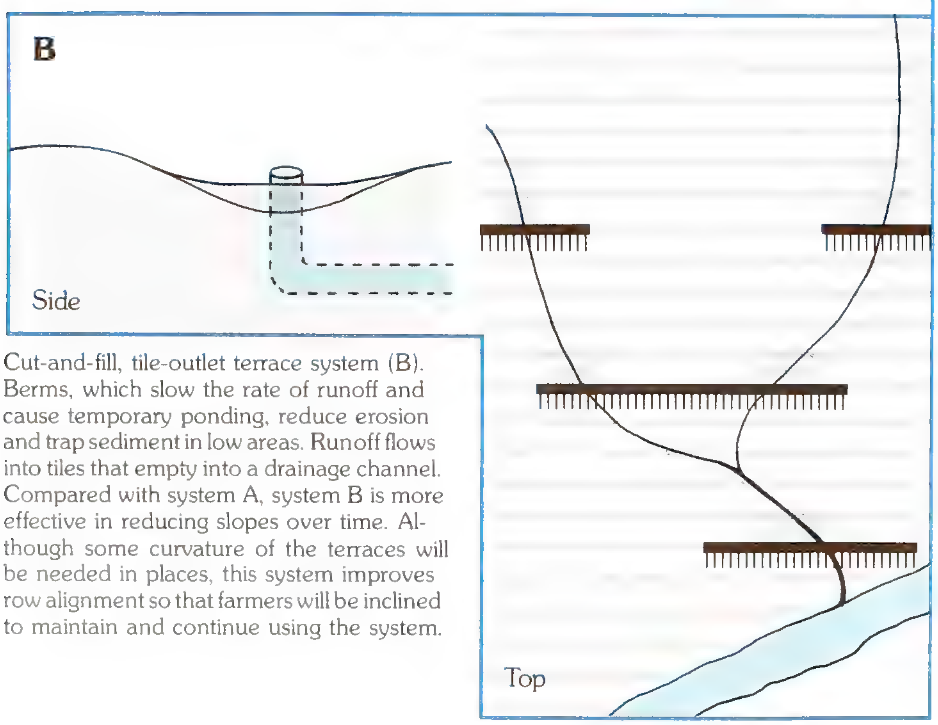
A good cover of crop residue protects the soil from splash erosion and retards surface flow.

Reclaiming Damaged Soils

Ivan J. Jansen and Joe B. Fehrenbacher



Contour grassed-waterway system (A). Suited to gently sloping land, this system helps reduce soil erosion over time. Short crop rows are inserted at intervals to accommodate to variations in the natural contours of a particular field. The system should be used in combination with conservation tillage practices.



Cut-and-fill, tile-outlet terrace system (B). Berms, which slow the rate of runoff and cause temporary ponding, reduce erosion and trap sediment in low areas. Runoff flows into tiles that empty into a drainage channel. Compared with system A, system B is more effective in reducing slopes over time. Although some curvature of the terraces will be needed in places, this system improves row alignment so that farmers will be inclined to maintain and continue using the system.

Once damaged by erosion, can land be restored to a productive condition? To answer this question, producers and others must consider the properties of the soils involved and the extent of the damage to them.

Two basic methods are used to reclaim eroded land: (1) rebuilding the remaining soil through intensive management, and (2) replacing the lost soil with material brought in from elsewhere. Rebuilding the soil can be successful only where the damaged soil still has good quality material of an adequate depth. Replacement requires a readily available source of suitable material such as sediment dredged from a lake.

Rebuilding the soil. The first step in planning the reclamation of eroded land is to make sure that the surface is stabilized so that future erosion will be held in check. Attempts to improve the soil would be pointless if it were allowed to erode at the same high rates that initially caused the damage. Erosion control plans must also be compatible with an economical use of the land; otherwise, future managers may be tempted to abandon control measures and allow the soil to degrade again.

Where practical, the plan should direct any unavoidable soil movement towards increasing the overall stability of the soil. To do so involves trapping sediment in low areas so that slopes will gradually decrease.

If the exposed subsoil is of good quality, a new topsoil can be developed in the remaining soil through intensive management. The decision will depend on several features of the subsoil: it should have a favorable texture and suitable chemical properties. In addition, it must be deep enough to allow normal plant rooting. Commonly, 4 to 5 feet is adequate, but the deeper the better.

Most eroded soils are low in organic matter. Generally this condition results in relatively poor tilth, strong crust formation, poor water infiltration, and a reduced supply of nitrogen. Where the texture of exposed materials is favorable, tilth and crusting problems can be overcome in most seasons by careful tillage management.

Intensive management, including ample fertilization, can help speed

the rebuilding process by increasing plant growth and thus the quantity of crop residues left after harvest. At best, however, adequate stands will be hard to achieve if adverse weather prevails during the planting season. As new organic matter accumulates, these problems will decline.

Decomposing organic matter supplies nitrogen to crops. Nitrogen fertilizer is more essential after erosion has removed part of the organic matter reserve from a soil than before. Under good management, though, the amount used on eroded soils is not much greater than that used on uneroded soils. But if a farmer taps the greater reserve of organic matter in uneroded soils, he depletes that reserve. Regardless of the level of organic matter, enough nitrogen fertilizer should be supplied to meet the needs of the crop without depleting the reserve.

Alternatives to reclamation. If the eroded land sits on top of bedrock or unfavorable subsoil material that hinders root development, the damage can be considered permanent. Short of hauling in material to replace the lost topsoil, the condition cannot be reversed (see box).

When reclamation is out of the question, the soil should be seeded to a permanent cover crop. The crop chosen must be compatible with the remaining soil and if possible have some beneficial use. Because erosion damage of these soils is virtually irreversible, erosion control will often involve a change in land use, for example from row crops to pasture or woodland.

In northeastern Illinois, the high clay glacial tills have such unfavorable subsoils that relatively little improvement can be expected, regardless of future management. The damage is done. At the other extreme, western Illinois has some of our best loess soils with highly favorable subsoils. With erosion control and careful management these soils can be made productive again. Falling between these two extremes, most Illinois soils can be partly, but not completely, reclaimed.

Ivan J. Jansen, associate professor of pedology; Joe B. Fehrenbacher, professor of pedology

Lake Paradise Regained

Walter D. Lembke

Replacing lost topsoil may seem like a task of epic proportions, but it can be done. The Lake Paradise project is a case in point. Spearheaded by a group of concerned citizens from the Mattoon area, the project got under way in 1981 with a $75,000 grant from the Illinois Department of Agriculture to the Illinois Agricultural Experiment Station.

The purpose of the one-year pilot study was to coordinate the return of lake sediment to agricultural land (see "Downstream Problems From Sediment," p. 8). Eventually the findings of the study will become part of a total watershed and lake management program.

Results of sediment analysis were already available through the Department of Agronomy, which had been funded for the work by the Illinois Institute of Natural Resources. According to the data, clay content was highest near the dam but steadily decreased towards the upstream end of the lake. Sediments with low clay content were preferred because they dewater rapidly and don't cause many drainage problems.

In general, the sediments in Lake Paradise were high in plant nutrients such as phosphorus and potassium and were comparable in organic matter and nitrogen content to topsoil in nearby fields. Because the pH was neutral to slightly alkaline, liming would be unnecessary for agricultural production. The sediments were also relatively free of pollutants; levels of pesticide residues, PCBs, hazardous hydrocarbons, placticizers, and heavy metals were well below acceptable limits.

In April, 1981, about 200 cubic yards of sediment was trucked from the upper end of the lake to a 0.1 acre plot on a farm one mile from the lake. Sediment was applied to depths of 12 and 18 inches; a check area was left untreated. The plots were all fertilized at levels recommended by the Department of Agronomy.

Plots with no sediment yielded 115 bushels of corn per acre. The plots with 12 inches of sediment produced 126 bushels, while those with 18 inches yielded 144 bushels.

In July, sediment was pumped by hydraulic dredge from the upper end of the lake to the farm site and into two one-acre terrace basins constructed to permit sediments and nutrients to settle while the water drained back into the lake. The Illinois State Water Survey monitored the water leaving the plots as it entered a tributary stream that flowed into Lake Paradise. Water from the test plots was of a better quality than water in the receiving stream. The terraces, which are to be placed into agricultural production this year, are designed for the use of 12-row equipment.

The Lake Paradise study is a significant step in soil conservation research. Success of the project will depend on the continuing cooperation between the agricultural and the urban communities.

Walter D. Lembke, professor of agricultural engineering

The Price Tag on Erosion and Conservation

Bartelt Eleveld

If soil erosion is so destructive and if many alternatives are available to control it, why don't all farmers use conservation practices? A few farmers may be uninformed or apathetic, but for most, the decision about what to do is based on the economics of the situation.

Many trade-offs influence the conservation decisions of landowners and farm operators. Some institutions and traditions of ownership and control in this country also contribute to the erosion problem. Furthermore, conservation needs vary greatly from farm to farm.

Economic goals. A number of underlying motives, some complementary and others conflicting, may guide a farmer's decision-making behavior. Not the least of these motives may be a subjective desire to be a good steward of the land. However, researchers and farmers alike find it difficult to quantify subjective goals.

A more objective and easily quantified goal is that of profit or net income maximization. Far from being sinister or corrupt, this goal is the same one that prompts most investors or savers to place their funds where returns will be highest. Agriculture is a competitive sector of the economy and as such is relatively free to entry and exit. According to one line of reasoning, farmers who emphasize profit maximizing over other possible goals are more likely to predominate because they will have money available to buy and control farmland.

We shall return to this question of economic goals later. First let us look at some of the cost and income trade-offs inherent in soil conservation decisions.

Cost effects. A combination of conservation practices is commonly referred to as a system. Usually more than one input in the production process is changed; consequently, various management practices need to be adjusted accordingly. Some of these changes may result in cost savings, others in cost additions.

One of the most common erosion abatement strategies is to reduce the amount of tillage and cultivation with an eye towards leaving more plant residues than usual on the surface. On the plus side, these residues absorb much of the kinetic energy of falling raindrops and help retard the speed of runoff water.

On the minus side, all reduced tillage systems tend to encourage weeds, insects, and diseases whose vectors may be harbored in residues. As a result, additional quantities of pesticides are usually necessary. Residues may also prevent complete incorporation of fertilizers, some of which tend to volatilize. The level of fertilizers, especially nitrogen, may therefore have to be increased.

These costs are offset somewhat by savings accruing from fewer trips over the field and a corresponding drop in expenditures for fuel, machinery repair, maintenance, and operator

labor. However, these savings must be juggled with losses in machinery efficiency that may occur when contouring or cultivating smaller fields requiring customized treatment.

Conservation tillage has opened the door to new expenses related to integrated pest management. Because some pests are able to build up a tolerance to certain pesticides, an increase of pesticide applications is undesirable. To avoid applying pesticides unnecessarily, fields must be scouted often and treated only when pest populations exceed economic damage thresholds. Scouting requires additional labor and technical expertise, which many farmers have to hire, at least until they can learn the techniques and adjust to additional labor demands.

Some conservation systems call for new capital investments. For example, reduced tillage or no tillage may require new equipment such as chisel plows and no-till planters. On the other hand, new equipment can often be phased in as replacements for worn-out or obsolete conventional equipment.

Probably the most expensive conservation measure per acre is the construction of permanent terraces to reduce slope length in a field. Although cost-share subsidies are available in some areas, the initial cost of these structures can be formidable. Also, they need periodic maintenance and prevent the use of certain types of machinery.

Income effects. The income side of the ledger must also be examined to evaluate the effects of conservation on profits. Only some of the effects discussed here will occur in any one conservation system, but all possibilities must be accounted for.

Changes in crop yields are of course the first place to look for income changes. Whether yields go up or down depends, among other things, on soil characteristics such as type, slope length and steepness, and degree of erosion; climate, including the amount and distribution of rainfall during the year; and drainage, which is partly a function of the soil and partly a function of investments in tile drains, ditches, and so forth. On poorly drained soils, for example, row-crop yields are lower with light to zero tillage than with conventional tillage.

Over the last eight to ten years, national farm policy has stimulated intensive row cropping on erosion-prone lands that had been left uncultivated or used for forage and cover crops. To farm this additional acreage, some farmers invested in the necessary capital equipment. Now, however, they are in a position where debt-servicing obligations on their investments make it difficult, if not impossible, to revert to less intensive land use.

Unfortunately, less intensive crop rotation is precisely what is needed to protect much of our land from damaging erosion. Yet the net income penalty can be considerable indeed when going from continuous row cropping to a rotation with several years of forage crops.

Some of the lands that are currently causing the worst erosion problems may even need to be withdrawn completely from row-crop production and converted to continuous pasture. The only feasible way to market that crop is to raise ruminant livestock, but prices in these markets are already depressed from overproduction.

Time preference for income. On vulnerable soils, the income-producing ability of the land can often be prolonged if soil conservation methods are used. Some farmers must choose between, on the one hand, a high income now with a low income after erosive practices have taken their toll or, on the other hand, a moderate income that can be sustained through time. Why do farmers often choose the former course rather than the latter?

Like most other people, farmers have a time preference for money. Perhaps an example would best illustrate the point. Suppose a farmer considers investing $800 in an enterprise that will return $1,000 one year from today. He knows that the $1,000 he will receive in a year is worth something less than that same amount today. But how much less?

The answer depends on his alternatives for investing the $800 in some other way. If his best alternative were to bank the money for one year at 10 percent interest, the $1,000 to be received in a year is worth about 10 percent less today, or $900, a figure that can then be compared with the $800 cost of the investment.

This subtraction process is called discounting, and the rate by which the future benefit is reduced is called the discount rate. In general, the present or discounted value of future benefits becomes smaller the further in the future the benefit will occur or the higher the discount rate. Because people with capital invested in farming have many other alternatives for investing those assets, the flow of income from different farming practices must be discounted.

Some farmers are opting for intensive practices that erode the soil because the present or discounted value of this flow of income is significantly greater than the present value of the conservation alternative. This situation is particularly true in three cases:

- where effective conservation would call for changes from row crops to forages
- where initial costs of certain conservation measures, such as terracing, are very high
- where significant yield losses are associated with the conservation method

The cash flow problems mentioned earlier also add to the severity of this discounting process because affected farmers already have, in a sense, higher discount rates. While trying to pay for land and new equipment, many farmers may have heavy nonfarm financial obligations as well, such as supporting children enrolled in college. Also, technology improvements in the past have boosted yields even though topsoil was being lost to erosion. Producers may expect future innovations to continue bailing them out of their erosion problems.

Public and private interests. So far only the concerns of private individuals have been discussed. However, the conservation issue affects the entire society for two basic reasons.

First, conservation versus exploitation will undoubtedly have some bearing on future generations. Do farmers, by exploiting soil resources today, have a right to burden future generations with a scarce and therefore expensive food supply? Conversely, does society have a right to expect an

inexpensive and plentiful food supply in the future at the cost of low incomes for today's farmers and resource owners? This is a classical dilemma for all scarce, depletable resources, not just for farmland.

The second major reason for society's concern with soil erosion is that sediment from farmland damages rivers, lakes, and streams, causing turbidity and polluting water with chemical toxins. These off-site damages continue unabated because the farmer does not have to bear the cost associated with them. Also, since the source of pollution is so diffuse, it is difficult to identify the offending fields and the amount of pollutants contributing to the problem.

In other industries where the pollution source, such as a drainpipe from a factory, is clear, the state has the power to impose regulations, fines, and plant closings. Although more difficult to regulate, agricultural pollution prompted the Clean Water Act with planning requirements outlined in Section 208. This legislation is forcing states to formulate plans for reducing erosion-related water pollution.

Future directions. In the early and mid-1970s Earl Swanson and his associates studied some of the economic trade-offs. They found that in many watersheds the off-site damages affecting society and the environment may be greater than the income losses to farmers from on-site erosion control. Apparently the public has a rather large stake in the matter.

In the past, conservation policy emphasized voluntary programs that appealed primarily to a farmer's self interest, often in the form of grants and cost sharing of conservation investments. But this approach is costly, may have only a temporary effect, and leaves in doubt the future availability of funding at levels sufficient to be effective. Because society bears the cost of agricultural pollution, it may be equitable to legislate nonvoluntary approaches. While precedents for similar action exist in other industries, the pros and cons of alternative approaches should be carefully weighed by policymakers.

Bartelt Eleveld, assistant professor of agricultural economics

As state soil erosion standards are tightened during the next two decades, erosion control systems will become a common sight in many parts of Illinois.

Strategies for Controlling Erosion

Robert D. Walker and Robert A. Pope

For more than four decades the United States has had a policy of controlling soil erosion, but although goals have been set, they have seldom been attained. However, erosion increases have been minimized and losses occasionally reduced. Despite these efforts, excessive erosion remains a problem on nearly a third of the nation's cropland.

Causes of soil erosion are neither superficial nor simple. Considering the magnitude of the problem, it is not likely to be solved with cosmetic actions. The problem is deeply rooted in international trade, traditional institutions, life-styles, and other complex phenomena.

Institutional aspects of the problem include land tenure arrangements, credit, taxes, and marketing systems. In addition, many farmers may be unaware that they are losing more than 5 tons of soil per acre or doubt that it matters with modern technology. Other farmers may not be fully informed about acceptable erosion control techniques or the long-term consequences of these practices and investments.

Over the years Illinois has used a number of old strategies, developed some new ones, and considered others. Some of these strategies are discussed in the section that follows. (See box on page 18 for a summary of legal strategies.)

Education and research. Most people agree that education is an important part of solving any problem. Increased educational efforts will therefore be aimed at helping landowners and operators understand the soil erosion standards of their districts, the erosion process, and the principles of erosion control. They will be taught ways of estimating their erosion losses, how to evaluate the effects of erosion on their land and on water quality, how to choose practices that can bring erosion under control in their particular situation, and the most effective use of technology.

Farmers will also be informed about financial resources, income, interest, tax breaks, and cost-share arrangements that are available to them in planning and implementing an erosion control program. Last but not least, the general public, including young people, will be shown how important soil conservation is to their future and how to help promote and carry out erosion control programs.

All of the information that is passed along to farmers will be solidly based on University of Illinois research findings. Many research projects are in the offing, but special consideration will be given to methods of stabilizing or controlling erosion during the fall, winter, and early spring on sloping land after soybean harvest; incentive systems and strategies for speeding up

the adoption of known technologies needed to conserve our soils; the effectiveness of applying soil conserva tion practices for improving water quality; and the effect of wind erosior on water and air quality.

Erosion standards. The state of Illinois has undertaken to reduce so erosion by the year 2000 to the estab lished soil loss tolerance of 1 to 5 tons per acre annually. As an interim goal, erosion is to be reduced to the soil loss tolerance by 1988 on all gently sloping land where erosion can be controlled with conservation tillage. These goals were developed through public hearings in accord with the 1978 amendment to the State Soil and Water Conservation Districts Law.

When district erosion standards are implemented on January 1, 1983, anyone can register a complaint against a landowner for excessive soil erosion. Upon determining that erosion is excessive, the district is required to work with the landowner in developing a plan to reduce erosion to district standards. If the landowner refuses, then the district must hold a public hearing to determine the reason for failure to comply.

Threat of regulation. At the public hearings held during development of the State Water Quality Management Plan, Illinois farmers made it clear that they do not want a regulatory soil erosion program. The federal Environmental Protection Agency agreed to a national voluntary program, but pointed out that the agency has a mandate to reduce water pollution. The agricultural community is therefore expected to take action in reducing soil erosion to improve water quality.

The Illinois Department of Agriculture is required to make an annual survey of reductions in soil erosion. At the end of five years (1984), the progress made will be evaluated and the need for regulations determined.

The Illinois Soil and Water Conservation Districts program that sets and administers soil erosion standards has put a complete regulatory program in place, except for fines. By further amending the district law, the state could impose fines for those having excessive soil erosion.

Allocation of resources. A major difficulty with past programs has been reaching farmers or landowners who have severe erosion problems. According to a 1980 national study of the Agricultural Conservation Program, 52 percent of the cost-share payments went for erosion practices on land with less than a 5-ton soil loss per acre.

In 1979 the Effingham, Illinois, Soil and Water Conservation District conducted a study of their erosion control efforts to help them allocate resources more effectively than in the past. They found that a majority of the district cooperators were on the best land with the least erosion. Districts and agencies are now attempting to direct their resources to areas having the greatest erosion problems.

Conservation incentive payments. For many years federal cost-share payments have been made to landowners to help them with soil conservation efforts. Funds have been spent for the more effective of the erosion control practices in recent years.

In 1981 the state of Illinois entered into a conservation tillage cost-share program with Illinois farmers. Despite the lack of state funds for continuing the program at this time, a trend may have been set for the future.

During 1982 the Illinois Agricultural Conservation Program will work with a few counties where cost-share payments will be based on the amount by which soil erosion is decreased. Farmers who decrease erosion by 5 tons per acre may get a 30 to 50 percent cost-share payment, while those with reductions of 10 tons or more may receive 50 to 75 percent.

Increased role of districts. Back in 1937 the state legislature delegated responsibility for erosion control to the Soil and Water Conservation Districts. Forty years later an amendment to the law directed the districts to expand their erosion control program. In addition, the State Water Quality Management Plan delegates to districts the responsibility for controlling water pollution caused by soil erosion.

The Soil Conservation Service has provided nearly all of the technical assistance to districts over the past forty years. Most of the cost-share funds have come from the Agricultural Stabilization and Conservation Service. Since 1980, districts have received additional state funds to provide cost-share money and to hire district employees. If districts are to get the job done, an increase in state or federal funding will be needed.

Public investment. In Illinois, 900,000 acres of land must be shifted to nonrow-crop production to meet state soil erosion standards. One way of shifting might be for the state to buy the row-cropping rights to this land; the farmer would be allowed to continue farming but could not grow any row crops on highly erosive land.

A second alternative might be for the state to buy the land and seed it down to grasses or plant it to trees. After it is protected, the land could be sold to the highest bidder, with a restriction prohibiting row-crop production or farming methods that cause excessive erosion.

Development of national policies. U.S. Department of Agriculture programs have had many objectives: to decrease or increase production, to assist with recovery from natural disaster, to help young people start farming, to help farmers get through difficult financial periods, and so forth. But most of the programs have given little consideration to long-term soil conservation. The Soil and Water Resources Conservation Act of 1977 has pointed out the need for a consistent soil conservation policy recognized in all USDA programs.

More feed grains than ever before are being produced for export to help maintain the balance of trade, to meet world food demands, and so on. Pressures on farmers to meet these demands tend to make it more profitable for them to grow feed grains than to produce livestock and livestock products. But livestock can use the forage crops that are an indispensable part of erosion control rotations on highly erosive lands. If we are to control soil erosion on hilly land, government programs are needed to help bring profits from livestock operations more in line with profits from grain crops.

Robert D. Walker, associate professor of natural resources, Extension;
Robert A. Pope, assistant professor of soils, Extension

When Government Steps In

C. Allen Bock

The legal alternatives for achieving soil conservation are varied and somewhat uncoordinated. However, certain trends can be defined.

Federal. Under the Resources Conservation Act of 1977, the U.S. Secretary of Agriculture was required to analyze soil and water resources by 1980; reappraisal is required every five years. The Act also requires the U.S. Department of Agriculture to prepare a program to conserve, protect, and enhance these resources. New proposals may include block grants to cooperating states; redirecting programs to address critical soil erosion areas; cross-compliance programs; and tax incentives.

State. Stronger state programs are also likely. In 1978 Illinois amended its Soil and Water Conservation Districts Act to require the State Soil and Water Districts Advisory Board to develop guidelines and coordinate a comprehensive state erosion and sediment control program. After adopting these guidelines, each district must in turn establish a control program that includes conservation standards for various types of soils and land uses. The Illinois Act provides for a complaint system within districts.

Compared with Illinois, some states have more stringent laws. All conservation districts in Iowa must establish regulations for soil loss limits, and landowners must use conservation practices to meet these regulations. If erosion exceeding the established limits is brought to the attention of the district, the landowner may be issued an administrative order requiring certain practices that can be enforced by court order. The Iowa Supreme Court has upheld these requirements. However, no new conservation structures can be mandated if at least 75 percent cost-share funds are not available to assist the landowner.

Some states have different types of cost-sharing arrangements. Illinois law, for example, requires that the district share part of the cost of devices, structures, and practices used for enduring erosion and sediment control. Other states provide low-cost loans (Nebraska), tax credits (South Carolina), and tax revenues or bond issues earmarked for conservation assistance (Montana and New Jersey).

Local. Local governments may use their regulatory authority to implement soil and water conservation standards. Illinois county and municipal ordinances recognize this authority to some extent. For example, local governments can prohibit some practices that contribute to soil erosion. However, an agricultural zoning approach prohibiting certain erosive practices on agricultural land would not be allowed under Illinois law.

Other alternatives. Purchase of cropping rights by federal, state, or local governments is a possible alternative. Funding continues to be a serious problem, however. There is also some doubt about landowner reaction to interference with traditional private property rights.

Tax credits might be provided for investment in conservation practices or equipment. A liberal dose of credit might create substantial interest among some landowners or operators. But there are few guarantees that farmers will use the right practices on the most vulnerable land. A tax credit will not provide much motivation for the farmer whose income generates little tax liability. Furthermore, we do not know what influence credits will have on the price of land if the credits are high enough to attract those looking for possible tax shelters.

Under a conservation incentive payment program, landowners would be paid according to the amount by which they reduce soil loss because of modifications in farming practices. Under a taxation program, landowners would be taxed for failing to reduce soil loss by a given amount over established loss tolerance levels. In both of these programs, accurate measurement is a problem. In addition, equitable treatment of landowners would be difficult because of the varying levels of erosion. Both proposals might therefore be resisted by landowners.

The potential advantages of a comprehensive cross-compliance program are discussed in the Council for Agricultural Science and Technology Report No. 92, issued in January of 1982, and by Libby in an article in a 1980 issue of the *Journal of Soil and Water Conservation*. The strongest approach would require individual producers, with the assistance of various incentives, to comply with erosion control measures in order to participate in government assistance programs. Standards would be set through the state soil and water conservation districts and their cooperating state and federal agencies and boards.

As Libby states in his article, "This approach [cross compliance] has something going for it — it makes sense."

C. Allen Bock, professor of agricultural law

Enforcement Issues

J. C. van Es

Ever since the Dust Bowl days, the government has had a hand in trying to combat soil erosion, yet the problem is still with us. Why has it been so difficult to find workable solutions?

Research has identified a number of problems related to implementing erosion control policies. The most salient is that control practices don't yield many immediate farm-firm economic benefits comparable to those gained from newly introduced production technology. The public, not individual farmers, are the main beneficiaries, since erosion control helps prevent pollution of urban water supplies and retards siltation of water systems.

Without improved soil erosion and sedimentation control, more and more Illinois municipalities will be faced with a dwindling supply of surface water. To make up for the deficiency, they will have to invest in costly programs to find new water supplies or to restore the holding capacity of existing lakes.

In the past, policymakers relied on persuasion when introducing new agricultural technology. They tend to feel that the same approach can be used to convince farmers to adopt erosion control practices. Agriculture is one of the few sectors of the economy that uses a voluntary approach to environmental control, probably because mandatory programs are faced with farmer resistance and difficult enforcement problems.

The Prohibition Era amply demonstrated the difficulty of trying to enforce a policy that lacks public support. Today, farmers and their leaders are just as opposed to programs that affect their autonomy in farm decision making. Strongly ideological, the opposition is based on widely held beliefs about individualism and independence, and is frequently reinforced by the perceived economic threat of regulation.

There are exceptions, however. Some mandatory programs in agriculture are well supported by farmers. Examples of such programs include public health requirements in the dairy and cattle industries, animal waste disposal regulations, pesticide applicator licensing, and local noxious weed control.

Support is an asset, but the success of most regulatory programs is also due to their enforceability. Erosion and sedimentation control programs face special enforcement problems for two major reasons. First, it is difficult to measure accurately the origin and extent of erosion. Without good measures of soil loss and in the absence of clear solutions, regulatory programs become vulnerable to charges of capriciousness and rigidity.

Secondly, it is difficult to develop enforcement policies that are both centralized and uniform. The problem would be less complicated if pollution sources were not so diffuse and if agriculture were not so sensitive to local variations in topography and land use. Even if the political will existed to enforce a regulatory program, the technical and legal resources are inadequate to the task without voluntary cooperation from virtually all farm operators.

Reliance on voluntary strategies is not without problems. The Cooperative Extension Service and other agencies have an excellent record of achieving changes in agricultural practices through voluntary programs. However, much of this work has focused on activities that are compatible with farmers' profit-maximizing efforts. When erosion control policies are aimed instead at the public welfare, farm profits may suffer. Little is known about the limits of a voluntary compliance program operating within the restraints of such economic parameters.

A second problem is that voluntary programs in erosion control have rarely, if ever, achieved full participation. Some farmers have chosen not to participate, thus undermining the success of programs.

Finally, voluntary programs face a serious challenge in selecting priorities for allocating resources. Past experience indicates that the greatest need for erosion control does not often coincide with a farmer's level of interest in combating the problem. Relatively minor erosion problems may be solved while major problem areas remain neglected.

So far, erosion control programs in Illinois rely almost exclusively on the voluntary cooperation of farmers and landowners. This approach has some major drawbacks, as do mandatory alternatives. Technology is necessary in solving Illinois's erosion problem, but without farmer participation, be it voluntary, mandatory, or a combination of the two, technological solutions will not suffice.

J. C. van Es, professor of rural sociology

In Progress

Games some pesticides play

When an insecticide doesn't work as expected, the first inclination may be to think that the insects have become resistant to it. Resistance, however, may not be the reason for the erratic results from a soil insecticide used to control corn rootworms. According to studies by agricultural entomologist Allan Felsot, carbofuran (Furadan) has rapidly degraded into nontoxic products within thirty days in some of the fields where poor performance was reported.

"We think certain microorganisms in the soil — bacteria or actinomycetes — are able to use this pesticide as an energy source. As they break down the pesticide, they gain energy from it," Felsot said. The extra energy gives these microbes a physiological advantage so that they tend to proliferate at a rapid rate. When the soil is again treated with the same chemical, they will break down the pesticide at an even faster pace.

Other pesticides are causing problems, too. Iowa, Wisconsin, and New Zealand report some instances where the herbicide Eradicane breaks down rapidly and gives poor weed control. A few accounts indicate that the organophosphate insecticide diazinon also breaks down quickly in some soils. Felsot said that at present he is unable to predict the type of soils where this problem could occur, although it doesn't seem to develop in soils with a pH below 6.

Resistance should not be overlooked, however. Anytime an insect population is hit with one class of chemical year after year, resistance is likely to develop. That's the danger of restricting the available chemicals to one class, Felsot notes. He said that using extenders, controlled-release formulations, and rotation of chemical classes are the best ways to combat poor insecticide performance.

Discomfort from MSG

The flushed, uncomfortable feeling that people sometimes experience after eating at a restaurant may be caused by getting a little too much monosodium glutamate (MSG), a commonly used flavor enhancer. Many ethnic foods, including those served in Chinese restaurants, are reported to cause these reactions, which have been dubbed the "Chinese restaurant syndrome." The syndrome may be aggravated by overeating, said food scientist John Erdman.

Although 1 to 2 percent of the population may be sensitive, he said there is no major toxic effect from MSG; it just causes discomfort. However, people on restricted salt diets should limit their use of MSG because of its high sodium content.

Some foods that contain MSG are mayonnaise, French dressing, canned tuna, and breaded shrimp. In the United States, MSG is produced from sugar beet molasses in a fermentation process. Many vegetables such as mushrooms, tomatoes, and peas have high levels of free glutamate, perhaps accounting for their ability to enhance the flavor of other foods.

Recreation spots close to home

With cheap fuel a thing of the past, the demand for urban recreation will increase in the lower Great Lakes metropolitan region. This heavily populated area, which includes Chicago, Cleveland, Detroit, Gary, and Milwaukee, does not have the western parks and mountains or the eastern seashore and forests to absorb the demand for outdoor recreation. But it does contain the 50,000-acre Cook County Forest Preserve District, one of the oldest and largest systems of urban natural areas.

"If urban natural areas are to fulfill the needs of people seeking new recreation outlets closer to home, they must be managed to protect the environment and meet the needs of the visitors," said forester Bob Young.

In a survey of 57 forest preserve sites in Cook County, Young questioned 1,200 people about their recreational interests. Three-fourths of those interviewed said they visited these areas with friends or family.

Relaxing was mentioned most often as a pastime at the preserve. Picnicking and talking also ranked high, while active pastimes included sports and hiking. Most of the respondents made short, frequent visits to the forest preserve, with more than half of the respondents planning to stay an hour or less.

Forest preserves provide urban residents with nearby recreation areas for activities such as picnicking and hiking.

With proper planning and management, many farm ponds in Illinois could be converted to commercial catfish production.

Fishing for profit

Fish farming may become a new wave in Illinois agriculture. Agricultural economist Randy Westgren thinks that catfish farming is potentially profitable in the state, especially as a source of supplemental income for Illinois farmers. Compared with traditional agriculture, however, aquacultural technology is in its infancy.

Producers can use farm ponds, small reservoirs, strip-mining lakes, power generation cooling lakes, and streams for fish farming. Because of various fixed costs, larger operations are more likely to realize a profit than smaller businesses. Westgren recommends developing four five-acre ponds. After a few years, producers can expect profits ranging from $625 to $1,250 per hectare (2.5 acres) a year when raising catfish, which currently retails for $2.80 a pound.

Fewer than 200 acres of water are being used in Illinois for commercial catfish production. Ponds for recreational fishing may raise this number to more than 300 acres. Alabama, Arkansas, and Mississippi together have more than 56,000 acres of ponds that are producing catfish. Yet the market potential for fish in Illinois far surpasses that of the southern states.

Parasites in humans and chickens

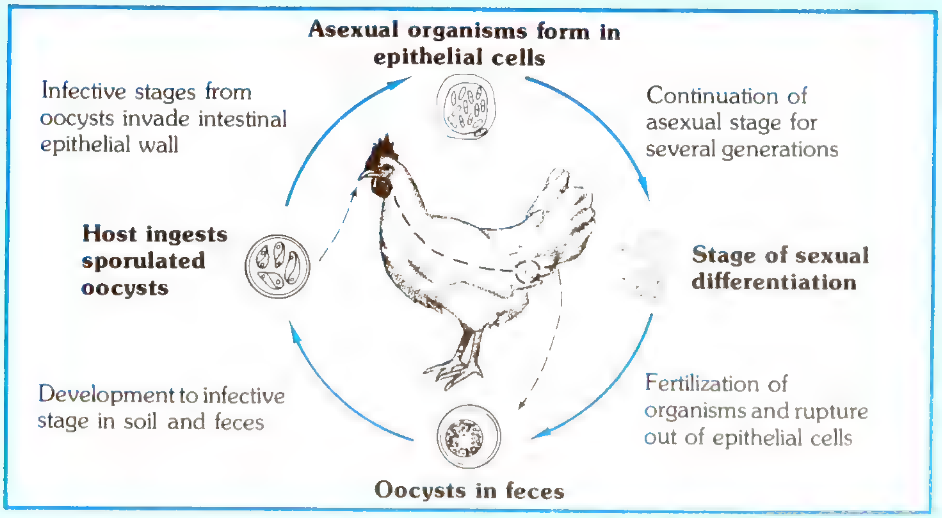
Intestinal parasites, especially in children, are a serious problem in parts of the developing world. Given the already precarious nutritional status of some people, additional problems caused by parasites can be devastating, said animal scientist David Baker. Baker and his colleagues are studying the effects of gastrointestinal parasites on digestion, absorption, and metabolism in the host.

The researchers have found that the damage parasites cause to the GI tract affects the rate of absorption of certain materials. The rate appears to be high for some heavy metals, which can accumulate in human and animal tissues, Baker said. Excess absorption could be of concern when PCBs, chlorinated hydrocarbons, and aflatoxin find their way into food channels.

As an aid to their research, the scientists are using the chicken as a model. Currently they are studying coccidiosis, an intestinal protozoan disease of tremendous economic importance to the poultry industry.

Developmental stages of *Eimeria* spp., intestinal parasites of chickens. Studies of these parasites are helping researchers understand how infestations affect digestion, absorption, and metabolism.

Adapted from: Principal Parasites of Domestic Animals in the United States. V. R. Ivens et al. 1978. Univ. of Ill. at Urbana-Champaign.



Forester Jeff Dawson examines alder seedlings being raised in a growth chamber.

Trees that nourish the soil

America has always had an abundance of forest resources to satisfy most of its wood and fiber needs, but this situation is not likely to continue forever. The U.S. Forest Service predicts that the demand for wood and paper will double by the year 2020.

Intensive tree farming systems using rapidly growing trees may someday become as common in the United States as they are in many European countries. In such systems, nitrogen-fixing trees and shrubs show promise for improving the productivity of marginal land. Grown with more valuable timber, they increase yields by adding nitrogen to the soil.

Forester Jeff Dawson has been studying the nitrogen fixation that occurs when microorganisms called actinomycetes form nodules on certain nonleguminous trees such as alder. He has found that this nitrogen-fixing capability can be increased by genetic selection of superior alders and actinomycetes. The result is faster growing alders and more productive soil.

University of Illinois at Urbana-Champaign
Agricultural Experiment Station • R.G. Cragle, Director
Urbana, Ill. 61801 • Publication • 11M

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Publications

More About Soil and Water Conservation

Publications listed in this column provide additional information about soil and water conservation. Requests for copies should be sent directly to the address provided after each title. Some of these publications may also be available at local public libraries or through inter-library loan.

America's Soil and Water: Conditions and Trends. 1980. 32p. No charge.
U.S. Department of Agriculture
Soil Conservation Service
P.O. Box 2890
Washington, D.C. 20013

Conservation Tillage: Regional Seminar 1981. 44p. No charge.
Robert D. Walker
University of Illinois
330 Mumford Hall
1301 West Gregory Drive
Urbana, Illinois 61801

Estimating Your Soil-Erosion Losses With the Universal Soil Loss Equation; by R. D. Walker and R. A. Pope. 1980. 17p. No charge.
Robert D. Walker
University of Illinois
330 Mumford Hall
1301 West Gregory Drive
Urbana, Illinois 61801

Soil and Water Resources: Research Priorities for the Nation; W. E. Larson et al., eds. 1981. 45p. No charge.
Soil Science Society of America
677 South Segoe Road
Madison, Wisconsin 53711

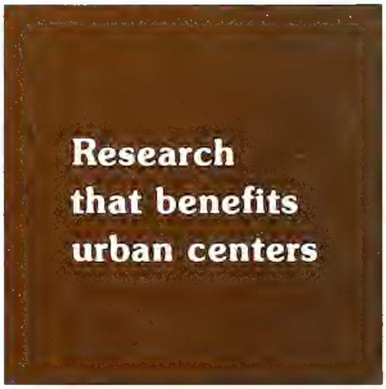
Soil Erosion: Its Agricultural, Environmental, and Socioeconomic Implications. Council for Agricultural Science and Technology (CAST) Report No. 92. 1982. 29p. $2.50 for nonmembers.
CAST
250 Memorial Union
Ames, Iowa 50011

State Erosion and Sediment Control Guidelines. 1980. 17p. No charge.
Illinois Department of Agriculture
Division of Natural Resources
Illinois State Fairgrounds
Springfield, Illinois 62706

Tillage Systems for Illinois; by J. C. Siemens et al. Illinois Cooperative Extension Service Circular 1172. 1980. 24p. No charge.
Office of Agricultural Publications
University of Illinois
123 Mumford Hall
1301 West Gregory Drive
Urbana, Illinois 61801

Illinois Research

Summer 1982



Renewal Notice

All readers who received a subscription renewal form with the winter issue of *Illinois Research* are asked to return the card as soon as possible. If we don't hear from you before the summer issue goes to press, your name will be dropped from the mailing list.

Readers who were not sent a renewal notice will automatically continue to receive *Illinois Research*.

Illinois Research

College of Agriculture, University of Illinois at Urbana-Champaign, Volume 24, Number 3

We're in a quandary. . . .

Many subscribers still have not responded to the renewal notice that was incorporated in a special wraparound cover on the winter issue of *Illinois Research*.

We don't want to drop anyone who has simply forgotten to return the card, but without it we have no way of knowing if a reader wants to remain on the subscription list.

If you received a renewal notice, please return it by November 22. If you've misplaced the form, a postcard will do, but be sure to include all of the information from your *Illinois Research* mailing label. For a change of address, copy down all of the old information as well as any changes.

Readers who were not sent a renewal notice will automatically continue to receive *Illinois Research*.

The Cover

Although geographically separate, farm and city are united by a mutually beneficial bond. Urban residents are dependent upon producers for food and for the continuing existence of a wide spectrum of occupations related to agriculture. Producers in turn depend on urban markets and on industries that manufacture products necessary to a modern agricultural system. Agricultural research therefore encompasses the needs of farmers and city dwellers alike. The cover illustration is the artist's conception of this relationship.

"At a time unlike any in the past, we must envision the future."

Illinois Research
Summer 1982
Volume 24, Number 3

Published quarterly by the University of Illinois Agricultural Experiment Station

Illinois Research

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1982 – Directions – 1992

Agriculture in an Urban Nation

In the space of just a few generations, America has become a nation of urban dwellers, in large part because of the modernization of agriculture. The continuing growth of agriculture is now highly dependent upon the technological developments of an urbanized economy. Many urban people are employed in industries that are part of our sophisticated agricultural system. Processing, transportation, marketing, research, and finance are but a few of the sectors of the economy directly or indirectly related to food and fiber production. The interrelationships between the rural and urban components of the economy have become increasingly complex and vital.

Today, rural communities and urban centers need each other more than ever before. The infrastructure that supplies the research, services, and materials used by farmers to meet the food needs of our own country and those of other nations can only be provided through cooperative rural-urban efforts.

Basic to the development of an advanced society is an adequate supply of food for an ever expanding population not engaged in production agriculture. Issues such as food safety, nutrition, land use, and agricultural policies have thus become as relevant to urban people as to those in the agricultural community.

The availability of energy is another concern touching everyone, regardless of residence. With dwindling supplies of fossil fuels, agriculture may one day be able to provide substantial supplies of energy from renewable sources. Therefore, our researchers are intensifying their investigation of methods for conserving and producing energy throughout the state.

Because of its commitment to urban and rural residents alike, the Illinois Agricultural Experiment Station is actively interested in households and communities, as well as in farmers and farm businesses. This issue of *Illinois Research* highlights some of the projects that take researchers into the urban environment.

Harvey J. Schweitzer, assistant director of the Agricultural Experiment Station

Agriculture in Urban Centers

Economics of Food Marketing

Randall E. Westgren

Since the era of subsistence farming in the 1800s, the distribution of food has evolved into a complex system that enables us to feed vast urban populations. As an important part of this process, meat packing and canning were centralized and transcontinental shipment established during the industrial revolution of the late 19th century. With staple foods being produced, processed, and shipped at low cost, less of the family budget had to be earmarked for food.

Since World War II, we have become part of a second industrial revolution, which gave rise to the affluent society. But as incomes rose, demand for staples trailed behind. Instead, consumers wanted highly processed convenience foods, frozen foods, national brands, imported cheeses, and so forth. Food manufacturers have responded with a bewildering array of products: a typical supermarket may carry 14,000 items.

Development of the modern food economy raises questions about the cost to consumers, the effects of the system on the quality of food and the diet, and future trends in food marketing with continuing increases in income.

Most foods that consumers purchase today bear little resemblance to commodities produced on Illinois farms because of extensive milling, freezing, cooking, extrusion, and other processes necessary to convert grains and livestock to common food products. Processing of this nature can be expensive. The relative value of farm commodities in the ultimate retail products is illustrated in Figure 1.

If the average farm value for all foods is only 37 percent of the retail value, what then constitutes the remainder? As Figure 2 shows, many elements make up the nonfarm value, labor being the largest among them. This total cost is called the marketing bill or farm-retail price spread. It represents the costs of processing, transportation, wholesaling, and retailing.

The popular press often applies the label "middleman" to these factors. During periods of rapid food price inflation, the middleman is usually blamed for profiteering. In point of fact, however, food manufacturers' profits lag behind the average for all industries. Supermarket firms are doing well to earn one cent on every dollar of sales.

Unfortunately, food price increases are an easy target for consumer dissatisfaction with inflation. Because consumers purchase food frequently, they can observe price increases for groceries more easily than for durable goods, housing, and most services. Although the middleman comes under fire, there is no pattern to the causes of food price increases over time. In a given year, increases may be due mainly to farm price fluctuations such as those brought on by the drought in 1980 or by the high export demand for grains in 1975; marketing costs including energy and labor; or the prices of imported foodstuffs such as coffee, sugar, and fish (Fig. 3).

Since 1975, food prices have increased less than inflation in general. Americans spent more than $300 billion on food in 1981, but this total accounted for only 22 percent of consumer income. Compared with nearly all other nations of the world, we still spend a smaller proportion of our disposable incomes on food.

Two phenomena of the U.S. food distribution system are noteworthy. First, more than $115 billion of the total food expenditure was spent

food eaten away from home, primarily in restaurants and fast food outlets. The United States nurtures a large and vigorously growing food service sector with some 250,000 eating places. Second, we are also seeing a renewed interest in direct-marketed food products. Many consumers prefer U-pick, farmers' markets, and roadside outlets to supermarkets as a source of fresh, high quality produce and other items.

Researchers at the University of Illinois have been investigating several aspects of these phenomena. For example, scientists from the Departments of Agricultural Economics, Family and Consumer Economics, and Foods and Nutrition are examining data from 15,000 households to establish food-away-from-home buying patterns. This research will identify effects of the increasing numbers of two-wage households on patterns of purchasing meals in restaurants, the relationship between eating away from home and the growing demand for beef and other foodstuffs, and the effect that eating out has on dietary adequacy.

Scientists from the Departments of Agricultural Economics and Horticulture have been studying what draws consumers to direct market outlets, how consumers measure product quality, and the extent to which direct marketing can expand as a source of farm income and consumer satisfaction.

In the future, consumers will continue to expect new and different foods. New products will proliferate, replacing many food products we now have. As consumers demand wholesomeness in food, more "natural" and fresh foods will be marketed. As consumers demand economical alternatives to national brands, more generic products will become available. As consumers demand high quality items, hydroponic vegetable production and other expensive alternatives will flourish. In short, the breadth of food product offerings will go on expanding to satisfy the preferences of consumers.

Randall E. Westgren, assistant professor of agricultural economics

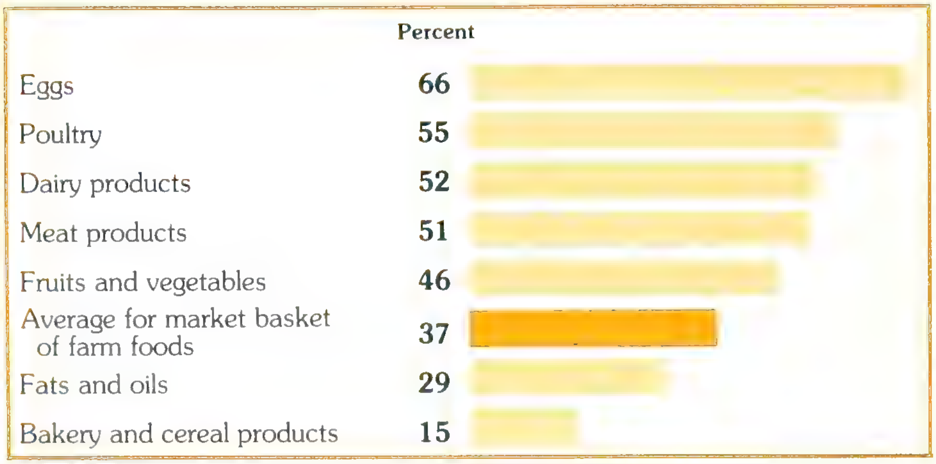


Fig. 1. Farm share of retail food prices, 1980 data (USDA), based on the payment to farmers for the farm products equivalent to foods in the market basket and the retail price. "Fruits and vegetables" includes both fresh and processed foods.

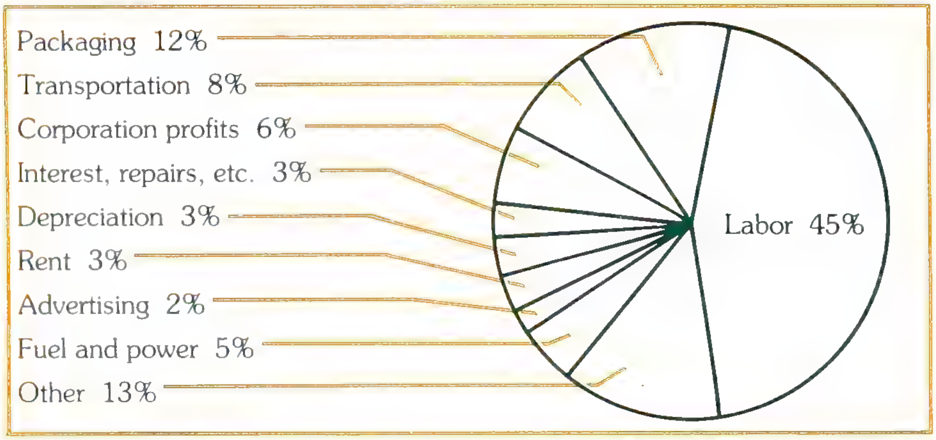


Fig. 2. Components of the farm-food marketing bill, preliminary 1980 data (USDA), based on foods marketed through food stores and away-from-home eating places. "Other" includes promotions, professional services, property taxes, local hired transportation, and insurance.

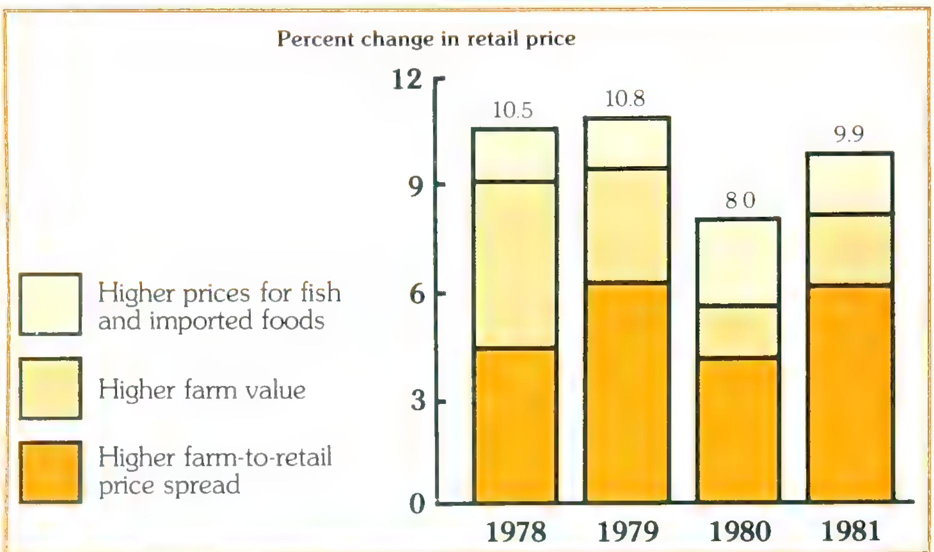


Fig. 3. Components of increases in retail food prices, 1981 forecast (USDA) for prices of fish and imported foods, farm value, and farm-to-retail price spread from U.S. farm-food market basket. Total price change from food-at-home index, Consumer Price Index.

The Politics of Food

Harold D. Guither and Harold G. Halcrow

Fifty years ago when the first farm price supports were adopted, the agricultural policymaking establishment was a relatively uncomplicated affair. It consisted basically of the major farm organizations, agriculture committees of Congress, the U.S. Department of Agriculture, and land grant universities. These groups didn't always agree on a course of action, but they did agree that it was up to them to decide what issues should be brought before Congress and the Administration.

Since then, this establishment has expanded greatly. In the last two decades, especially since the early 1970s, hundreds of organizations and groups concerned with some aspect of agricultural and food policy clamor to be heard. In addition to producers, these groups represent agricultural and food firms, industry, consumers, environmentalists, public institutions and agencies, and research organizations.

Producer groups. Producer organizations trying to influence policy have proliferated over the years. Five general farm organizations representing all types of producers draw members from most states and regions. The American Farm Bureau Federation is by far the largest, with more than three million members. The National Grange, the oldest of the five, has 450,000 farm and rural family members. The National Farmers Union stands at 275,000 members, mainly from the Great Plains and the Midwest. The National Farmers Organization, begun in 1955, and the American Agriculture Movement, organized in 1979, are smaller and more militant; membership figures are not reported.

Commodity organizations, most of which have representatives in Washington, D.C., have developed legislative and lobbying activities. In Illinois the most active groups are the milk producers, pork producers, cattlemen, soybean growers, and corn growers. Each state group is affiliated with a national organization, which concentrates on problems and concerns of the producers.

Farmer-owned cooperatives influence policy that affects their business. Often of special interest to them are transportation, energy, taxes, and marketing practices.

Two national organizations of farm wives are active in efforts to protect family farms and financial interests of farm families and to represent agriculture to nonfarm groups. American Agri-Women has more than twenty affiliated state and commodity-oriented farm women's groups, among them Illinois Women for Agriculture. Women Involved in Farm Economics, an independent organization concentrated in the Great Plains, generally supports the positions of the major farm organizations to which their husbands belong.

Business and industry. Agricultural and food firms and industrial organizations support the largest number of lobbyists in agricultural and food policy. During 1977 and 1978, for example, some 240 such groups were involved in lobbying or in legislative activity. In 1981, more than fifty testified at House and Senate hearings on the new Agriculture and Food Act.

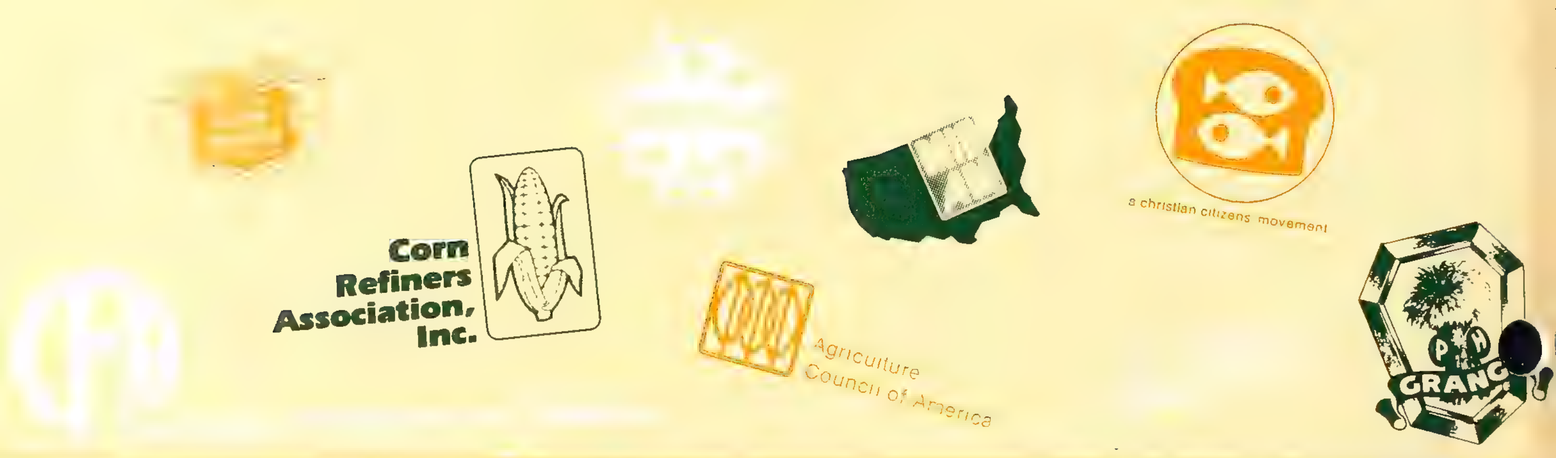
Groups represented included trade organizations whose members manufacture and sell farm inputs such as fertilizers, seed, feed, petroleum products, chemicals, and machinery. Also represented were agribusiness firms and organizations that process and market farm food products for domestic use and for export. Often enough their interests are in line with those of farm producer groups, but occasionally they may oppose farmers or have common interests with consumers.

Agribusiness groups are highly specialized. Practically every major farm input and farm food product industry has a Washington representative attempting to influence policy in Congress and federal agencies. Highly trained, well financed, and skillful in dealing with Congress and officials in the executive branch, these representatives often provide important and useful information as they present the positions of their organizations.

Consumer and citizen groups. More and more consumer and citizen groups, sometimes referred to as public interest groups, have become active in agricultural and food policy. Advocacy groups support food assistance and rural development programs for the poor to help them obtain food stamps and other benefits. Legislation on migratory farm workers has led to organizations that help these workers use the government assistance provided. More attention to the needs of the hungry and malnourished has stimulated church groups and others to improve food assistance programs both at home and overseas. Antipoverty and rural housing programs have encouraged groups in helping to implement these programs.

Wildlife and environmental groups actively promote policies for controlling the use of pesticides and for encouraging organic farming. With the growing concentration of large farms, organizations are now advocating increased support for small and medium-sized farms, social justice for farm workers, direct marketing of farm products, and increased land ownership among minorities.

Membership funding of citizen and consumer groups is limited, so they



must seek contracts and grants from foundations and federal and state agencies. As the budgets of government agencies are cut back, however, these groups face financial stress, and many have ceased or greatly reduced their activities.

Other organizations. Many public institutions and agencies form professional associations and often maintain representation in Washington, D.C. Although they may not lobby, they do communicate with policymakers and take part in legislative hearings. Included in this category are the National Association of Conservation Districts, the National Association of State Universities and Land Grant Colleges, the Association of Veterinary Medical Colleges, the National Association of Counties, and the American Public Welfare Association.

Professional associations with a continuing concern in policy include the American Veterinary Medical Association, American Dietetic Association, American Society of Professional Farm Managers and Rural Appraisers, and the American School Food Service.

Although not necessarily involved directly in legislation and lobbying, certain organizations engage in research and information activities that provide support for activist, lobbying, and legislative groups. Examples of such organizations are the Council for Agricultural Science and Technology (CAST), the Agriculture Council of America, the Conservation Foundation, the American Enterprise Institute for Public Policy Research, Resources for the Future, and the Brookings Institution. Some have specific interests in agricultural and food-related topics, while others have a much broader policy interest that includes some aspect of food.

Strategies and methods. Efforts to influence policy take several forms:

- direct contact between professional lobbyists and members of Congress or agency heads who make policy decisions
- letter-writing campaigns organized by the national office and directed to members during critical periods of mark-up (bill writing) and roll call
- group visits of constituents to the members of Congress who represent the constituents' state or district
- testimony of organization officers at committee hearings on issues of special concern

Some organizations keep a low profile. Their legislative activities may involve publishing an educational newsletter and urging members to voice their concerns on certain laws to Congressional representatives. Other groups serve as Washington contact points for members who want information unavailable elsewhere. A group that cannot afford to rent office space and keep a full-time staff in Washington, D.C., may hire one person who represents other groups as well.

To be more effective on a single issue, one group may form a coalition with other organizations having similar policy positions on that issue. Coalitions tend to come and go. Once a decision has been made on a bill or regulation, the coalition usually disbands. It may form again when issues of common interest appear in the future.

Another form of mutual assistance is the practice known as networking, which is prevalent among citizen and consumer groups with small memberships and limited funds. Networking involves publicizing another group's activities, having the same board member on their respective boards, and having members of one organization serve as consultants or committee members for activities of the other group. Through networking, groups form coalitions, testify jointly at Congressional hearings, and meet at conferences to develop plans for future activities.

Political action committees. Agricultural and food organizations have organized political action committees (PACs) to raise funds and contribute to the campaigns of candidates for Congress, the Presidency, and state legislatures. Compared with contributions collected by other business, professional, and labor groups, these funds are relatively modest, but some are large enough to be very significant. In the 1978 Congressional campaign, the five largest PACs were sponsored by the Dairymen Inc., the Chicago Mercantile Exchange, the Associated Milk Producers Inc., the Mid-America Dairymen Inc., and the National Rural Electric Cooperative Association. Contributions ranged from $217,000 to $456,000.

Most groups that sponsor PACs do not always expect to influence the votes of those successful candidates whom they support. They do expect their contributions to give them some recognition and to make communication of their views possible during future legislative activities.

Diversity of interests. The growing numbers of organizations concerned with agricultural and food policy issues provide diverse input into the policymaking process. Along with this growth, traditional farm organizations face increasing competition for attention from Congressional committees and members of Congress.

CNI
Community Nutrition Institute

NRECA
National Rural Electric Cooperative Association

Increased numbers of producer organizations, as well as business, citizen, institutional, and professional groups, make it difficult for Congress to reach a consensus. The long, drawn-out process of writing and passing the 1981 Agriculture and Food Act is an example. Dissatisfaction with final decisions is not uncommon.

With the increasing diversity of interests, the dominance or control of some issues by specific commodity groups is sometimes weakened. Attacks on the dairy, sugar, peanut, and tobacco programs during the debate on the 1981 Agriculture and Food Act reflects this development. In this case, the commodity groups were able to compromise and retain some special advantages. But future farm policymaking efforts could see greater influence by consumer groups and less control by the special commodity interests.

All of the groups discussed here have considerable influence. Yet individuals can also make significant contributions to the process of agricultural and food policymaking. As citizens we should understand how policy decisions affect us and our communities and businesses. We have a responsibility to vote, and we have the opportunity to write directly to legislators, members of Congress, and government officials.

Harold D. Guither, professor of agricultural policy; Harold G. Halcrow, professor of agricultural economics

Strategies for Fighting Inflation

Kathryn D. Rettig

Inflation and limited supplies of natural resources are tampering with the well-being of families and society as a whole. Pressured by changes in the economic environment, families have been forced during the last five years to make many adjustments in housing, transportation, food, and other consumer goods and services. Some serious rethinking of how to use available resources is going on in many households, as well as in other parts of our society.

Futurist scholars are trying to help this process along by suggesting options. Alternatives range from doing more with less, through doing the same with less, and doing less with less. Most families recognize the need to conserve resources, but show little enthusiasm for changing their life-styles when global needs are at stake. People find it hard to realize that individual decisions can have a cumulative effect on the natural and economic environments.

What kinds of adjustments are families making, and how do they feel about the changes? A study begun in 1980 by the Department of Family and Consumer Economics looked for answers to these questions. Specifically, the investigators wondered how Illinois families were coping with rising prices, whether they were aware of changes in their life-styles as a result of adjustment strategies, and whether these strategies affected their well-being.

Illinois families living in Chicago, Springfield, and Paxton were interviewed. Most couples were 43 to 45 years of age, had 13 years of schooling, and one child living at home. Family income was about $22,500 to $25,000, with an average per capita income of $5,000 to $7,000.

Family economic well-being, which was the central concern of the study, was measured by examining what are known as objective and perceptual indicators. Objective indicators describe the environment and conditions of life, the context of personal experience. One objective indicator, the Consumer Price Index, showed that the economic environment of families was stressful.

Although the index for all consumer goods rose 42 percent between 1978 and 1981, price increases were not uniform for all products. Internal variations from one family to the next can also be assumed. According to the index, transportation increased by 53 percent, housing 48 percent, medical bills 36 percent, food 31 percent, entertainment 25 percent, and clothing 18 percent.

Perceptual indicators are an individual's evaluation of how the quality of life has changed. When asked about their economic well-being, Illinois residents reflected what the Consumer Price Index indicated for the nation. The majority (72 percent) felt that family income had not kept up with price increases. A large proportion (44 percent) indicated that their families were worse off financially than two years earlier. More than half said that the quality of their lives had been adversely affected by inflation. All reported using at least one of several strategies for adjusting to inflation.

Increasing income. During the last decade, a common strategy for beating inflation was to send additional family members into the labor force. For married women, the rate of participation in the national labor force was 51 percent. In the Illinois study, 57 percent of the wives had full-time or part-time employment. Also, husbands tended to work overtime. Compared with the national average of 35.4 hours per week, the men surveyed averaged 42.6 hours.

The strategy of adding a second income earner was used less frequently when per capita family income increased. Many families who had recently adopted this strategy said that the quality of their lives had declined. This response was especially common among families with per capita incomes of less than $8,000.

Few families reported using other

income-increasing strategies such as selling assets, shifting assets to investment alternatives earning higher interest rates, renting property, or moonlighting.

Decreasing expenditures. Nearly all of the families in the study (99 percent) reported gradually adopting strategies for using less. During 1980-81 they bought less food, alcohol, and clothing, cut down on home energy, drove less, did not go out to movies and dinner as often, and took fewer vacations.

More than a fifth of the families went to the doctor and dentist less often than in the previous two years. However, medical and dental cutbacks were more common among lower than upper income families (40 percent compared with 25 percent).

Families with per capita incomes in the upper mid-range of $8,000 to $12,000 adopted the "using less" strategy more often than did families with lower or higher incomes. Out of necessity, lower income families were probably using less anyway, while upper income families seldom felt the need to decrease consumption except in the use of household and transportation energy.

The upper income families who did cut down on consumption usually said that the quality of their lives had been affected by this strategy, particularly when it involved less leisure, travel, and clothing. All income groups were dissatisfied about having less clothing and leisure, but were not as uncomfortable with reductions in food and travel.

Extending resources. In addition to increasing income and decreasing consumption, some families are trying to use existing resources to best advantage, thereby extending their use. To do so requires comprehensive, long-term planning; home production of goods and services; effective shopping; changing standards; recycling goods; improving energy efficiency; and substituting one resource for another.

Improved planning was reported by 22 percent of the families. This strategy may have involved consolidating automobile trips, coordinating wardrobes, changing the timing of decisions, or moving savings into favorable tax positions. As per capita incomes rose, the percentage of families reporting increases in comprehensive planning declined. More planners than nonplanners said that the quality of their lives had not been affected by inflation. This difference in respondents seems to indicate the value of comprehensive planning as an economic adjustment strategy and the probability that it contributes to a sense of accomplishment.

Increasing the production of goods and services at home was reported by 68 percent of the respondents, especially by the younger and lower income families. Relatively few of those at higher income levels reported activities of this nature, and many who did said that the quality of their lives had been adversely affected. Home production requires reallocation of time, perhaps from enjoyable leisure activities, to prepare more meals at home, maintain the house and car, plant and care for a vegetable garden, make clothing, and the like. This strategy tends to require more extensive adjustment in the use of time than does the "using less" strategy. Hence people may feel more uncomfortable and dissatisfied during the early period of adoption. For example, many families may be reluctant to give up leisure time for growing and preserving food at home, even though these activities may, under certain circumstances, help reduce the total amount of energy consumed by our society.

Changing standards can often lead to feelings of discomfort, since the strategy may involve the acceptance of lower quality goods or at least settling for less expensive food, clothing, vacations, restaurants, and the like. The strategy was adopted by 79 percent of the respondents, many of whom were in the lower income group. Most families using this strategy (94 percent of the lower and 83 percent of the higher income groups) reported that the quality of their lives had declined because of inflation.

All but one percent of the Illinois respondents were gradually developing strategies for shopping more effectively. Typical ways of doing so were by studying advertisements for sales, using coupons, and shopping at discount stores, cooperatives, secondhand stores, garage sales, and self-service gas stations. Some of these strategies are more time consuming than others and hence were used most often in families where the wife was not employed outside the home. Most respondents did not feel that the quality of their lives had been significantly affected by these strategies.

Some families who substituted one resource for another in an attempt to maintain valued life-styles felt that the quality of their lives had suffered. Most of these respondents were from families with per capita incomes of more than $12,000 a year. Resource substitution included taking advantage of community events and free entertainment in parks, and using public transportation rather than purchasing additional cars. These families spent more leisure time entertaining friends at home and watching television than "going out" or attending movies. Lower income families using this strategy were not as likely to say that the quality of their lives had been affected, perhaps because the adjustment was nothing new for them.

Exchanging resources. Futurist thinkers suggest the need for shifting from the ethic of ownership to the ethic of availability. Families can make this shift by renting rather than buying seldom used equipment or by exchanging goods and services with other households. For example, one family owning a wheelbarrow might exchange it for a neighbor's electric weed trimmer.

Families in this study were not conscious of resource exchange as an economic adjustment strategy. Only one percent claimed that they bartered or exchanged goods and services. However, the practice may be more common than the results of this study indicate. A few families also pooled resources, for example to buy vacation homes and to prepare potluck dinners. This type of adjustment is expected to become more common in future years.

Resource investment. Capital investments in durable goods were consciously made by a few families in order to use resources as efficiently as possible. Installing storm windows and insulation or buying fuel-efficient cars

were frequently mentioned. Making human capital investments in health and education are additional ways of improving the family's future economic well-being, but only 4 percent reported this type of investment.

The economic environment of families has been particularly stressful in the past five years because of both inflation and recession. Strategies available to families range from minimal to extensive adjustments in their way of life. The more extensive the reductions in consumption, the more society will benefit from the conservation of energy and other resources.

It is likely that significant conservation could result from doing more with less. These strategies involve selective buying, recycling, careful disposal, pooling resources, renting items, and careful management. The evidence suggests that families are now making many adjustments of this type in response to economic pressures, and are experiencing some consequences to the quality of their lives. Educators should continue to help families adopt the conservation ethic and to understand the effects of their production and consumption decisions on the environment.

Kathryn D. Rettig, assistant professor of family resource management

When the family dollar won't go far enough . . .

Increase income

Add second income
Work overtime
Postpone retirement
Sell unused goods
Shift assets to higher interest
Increase rent on rental property

Decrease expenditures

Buy less food, alcohol, clothing
Cut down on home energy by:
- Turning out lights
- Turning down heat
- Turning off air conditioner

Take fewer vacations
Eat fewer meals in restaurants

Extend resources

Produce goods such as:
- Clothing, furniture, draperies
- Fruits, vegetables
- Toys, gifts

Process food by:
- Canning, freezing
- Drying, pickling

Change standards for:
- Food, clothing
- Housing, entertainment

Produce services such as:
- Hair cutting, house repair
- Health care, care of elderly

Recycle household materials:
- Use leftovers more effectively
- Recondition clothing
- Use existing materials in new ways (e.g., scraps for crafts)

Curtail use of:
- Meat, liquor
- Convenience and junk foods

Change means of transportation:
- Join car pool, travel less
- Use public transportation
- Bike, walk
- Consolidate trips for errands

Substitute resources

Use other forms of energy:
- Firewood, solar energy
- Windpower
- Wear more clothes indoors during cool weather

Take advantage of free entertainment:
- Parks, community events
- Home entertainment
- TV movies, potluck suppers

Look into health care:
- Use free clinics
- Review insurance needs

Improve shopping strategies

Use alternative sources of supply:
- Secondhand, discount, wholesale stores
- Garage sales, farmers' markets
- Commissaries, auctions
- Cooperatives, U-pick

Use human skills:
- Buy in quantity or bulk
- Use coupons, double-coupon days
- Save labels, get rebates
- Read ads for best buys
- Buy generic and store brands
- Go to matinees, not evening shows

Sharpen planning strategies

Time decisions by:
- Delaying purchases
- Postponing vacations
- Waiting to remodel

Clarify important priorities for the use of money
Plan the best use of:
- Food, money
- Transportation, equipment
- Clothing

Make human and capital investments

Learn new skills such as:
- Auto repair
- Word processing
- Computer programming

Consider capital investments such as:
- Buying fuel-efficient car
- Installing insulation, storm windows
- Purchasing assets that appreciate

Production of Goods, Services, and Energy in the Home

Kerry R. Livengood and Robert A. Herendeen

Urbanites have traditionally been viewed as consumers rather than producers. Economists are now beginning to take into account the fact that many households are capable of producing highly valued commodities and services that include clothing, vegetables, repairs to the house and furnishings, and family recreation such as playing musical instruments.

At this end of the production continuum, people combine considerable amounts of labor and experience. At the other end of the continuum, households buy TV dinners, nonparticipatory forms of entertainment, and ready-made clothing, none of which requires nearly as much labor, time, or training on the part of the consumer.

If homemakers (both women and men) were paid appropriate wages, work carried on in the home would be equal to almost a third of the gross national product and half of all disposable income. To put it another way, the value of labor in the home is greater than paid income in the manufacturing industry.

In the context of home production, the house can be considered a factory, and as such is the major investment of the household. Refrigerators, sewing machines, washers, dryers, cooking ranges, and tools are the capital equipment needed for producing goods and services at home. The returns to this investment are much higher in many cases than the returns to other investments such as stocks and bonds.

Since World War II, the market economy has had a tendency to expand at the expense of the environment and the household economy. This trend may be slowing now that consumers are finding it hard to keep up with rising prices, especially of food and energy.

Convenience foods, for instance, may not be much of a bargain after all. About 66 cents of every dollar spent for them is absorbed by processing, packaging, and marketing, while only 33 cents is accounted for by the food itself. In some cases, the value of the time saved over preparing the meal from scratch is less than the extra cost of the convenience food. Some prepared foods don't even save time. Their only advantage is that the user can get by with less planning and skill than a home-cooked meal requires.

Now, however, rising food and energy prices are forcing consumers to become increasingly self-reliant. There has been a boom in home activities that produce anything from furniture to residential heat. In 1975 nearly half of the households in the United States had some form of vegetable garden, and a quarter preserved some of their own food supply.

Home production may not always be economically or technically efficient, however. Returns per hour of effort are often low. For example, in a 1978 study of a garden plot measuring 150 square feet, returns to labor were found to be about $1.08 per hour.

The household use of firewood is another example. Investments in equipment to harvest, transport, and burn wood are often considerable, so unless the wood is used in an efficient stove, there may be no monetary or energy gain. In urban areas especially, the price of wood is much higher than the price of the equivalent energy from other sources.

Nevertheless, home production may have recreational and aesthetic aspects that should be taken into account. Although difficult to analyze objectively, the intangible values in gardening, lawn care, firewood production, and other such activities may compensate for the low returns to labor.

This shift of the household from a consumer to a producer orientation has implications for research and education. We must determine methods for increasing household efficiency through improved management of family finances, gardening in small areas, growing and burning firewood, and through a host of other production activities. In turn, we need to find effective avenues for converying such methods to household members.

Improving the efficiency of our consumption patterns can be just as important as increasing home production. Energy use is an especially important area, since all household consumption, from gasoline to bread, involves energy somewhere. For an average household, about half of its total energy requirement is accounted

for by heating fuel, electricity, and auto fuel. The other half is consumed indirectly in the production of nonenergy commodities such as food, clothing, and recreation.

Efficient use of energy may or may not require changes in the way people live. Many measures that improve the efficiency of residential energy require no changes and may even have a positive effect on comfort and convenience. Compared with a poorly insulated house, one that is well insulated uses less energy and is more comfortable as well. Estimates of some broad means for improving physical efficiency are presented in Table 1. The measures sketched here add up to roughly 30 percent of a household's total energy use.

Households also have the potential for producing their own energy (Table 1). The dividing line between production and consumption is often fuzzy. We rather arbitrarily list as production the use of landscaping or tree plantings to reduce the need for air conditioning. Solar heat is an obvious heating option for a home, although the cost of installation is still rather high. Landscaping, tree planting, firewood production, and gardening add up to about 8 percent of the total energy used by a household.

In Table 1 we have indicated those projects that take time and labor, for example sorting solid waste and tending a garden. Some people feel that the loss of free time diminishes the quality of life. Others view these activities as an enjoyable, productive use of their time and as ways of strengthening family unity, creating good work habits, and fostering a sense of self-reliance.

For many decades the Illinois Agricultural Experiment Station has provided information and guidance to farmers, who are producers in a recognized and time-honored tradition. With the broader view of production outlined here, the Station can help urbanites become producers, too.

Kerry R. Livengood and Robert A. Herendeen, assistant professors in the Department of Forestry

Table 1. ***Energy Management in the Household Through Efficient Consumption or Actual Production***

	Pct. of household's total energy[a]	Energy-saving or producing measures	Pct. energy reduction possible	Cost effective?	Perceived effect on comfort or leisure time
Consumption					
Heating and appliances	33	Thermal tightening of house Using efficient appliances	50	Yes	No effect to some increase
Transportation	17	Driving fuel-efficient cars Using mass transit	50	Yes	Some to considerable decrease
Materials	3	Composting organic materials Sorting and recycling refuse	50	To society, yes, but not always to consumers	Some decrease
Lawn and garden	1	Reducing chemical use	50	Yes	Some decrease
Equipment	2	Exchanging lawn mowers, ladders, etc. with neighbors	50	Yes	Some decrease
Production					
Heating, cooling, light	33	Heating water and space with solar energy	60	Depends on cost of competing energy source	No effect to some decrease
(These three measures may be interdependent)		Heating with wood	80	Depends on prices of wood and competing fuel	No effect to some decrease
		Landscaping with windbreaks and shade trees	10	Yes	Some increase
Food	11	Intensive home or community gardening	20	Not unless labor is considered cheap	Some decrease

[a] "Total energy" refers to all the energy consumed in the economy to support a household's consumption of all goods and services. For the average family, total energy is roughly double the sum of residential heat, light, and auto fuel.

Heating and Cooling With Windows

Michael P. Sherman

For a great many years, people have been aware that windows can let cold air in and warm air out during wintertime. As early as the 1920s, researchers studied the leakage of air around windows under various conditions. Cures for thermal losses in winter and gains in summer have included window shutters, quilting, roller shades, deflector film, double glazing, storm windows, and draperies. Some architects have even eliminated windows entirely in new or remodeled buildings.

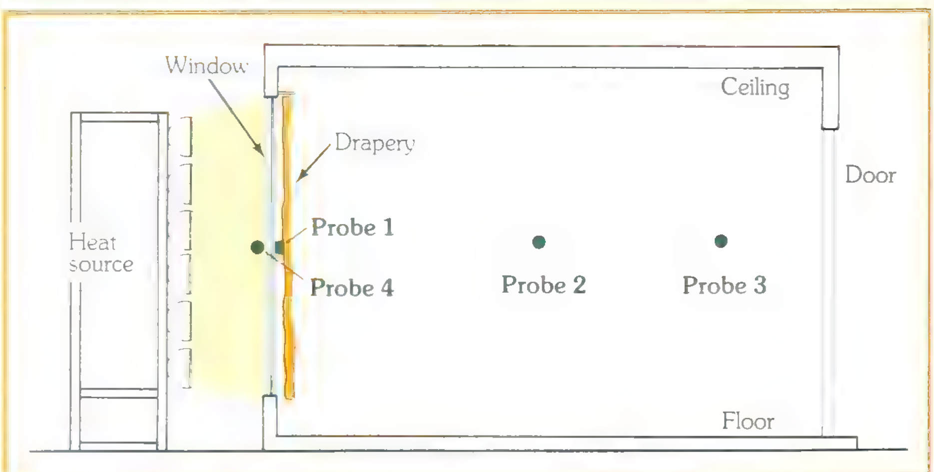
Properly managed, however, windows can serve as passive solar collectors during cold weather and as natural cooling devices during the summertime. With an elementary understanding of thermodynamics and a few basic materials, householders may soon be able to produce, as well as conserve, energy in their homes.

An important principle to keep in mind is that ordinary window glass conducts heat, often in the direction least desired: from a warm room to the outside in winter and vice versa in summer. The trick is to capture and release solar-heated air so that natural convection currents can carry it in the direction needed to keep indoor temperatures comfortable.

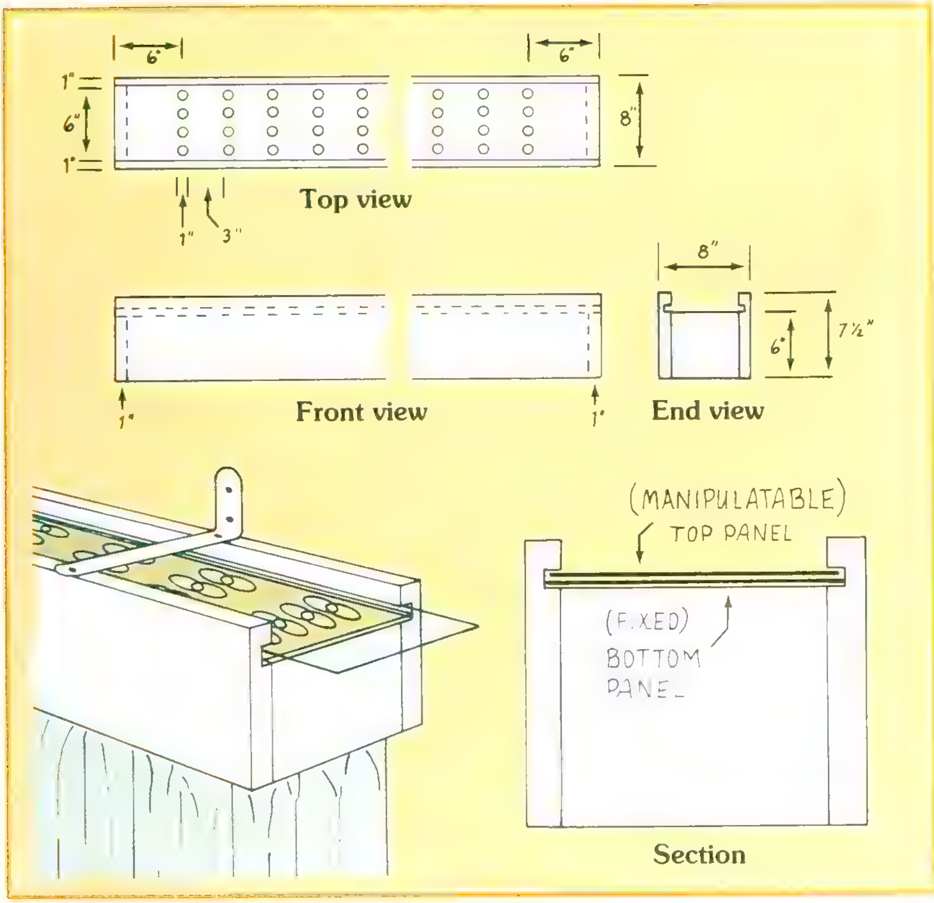
To devise an energy effective treatment for windows, my research assistant and I first had to construct a controlled-environment room within our laboratory. The room is 20 feet long, 10 feet wide, and 8 feet high. All six sides are wrapped in kraft-backed fiberglass insulation and covered with a vapor barrier. The interior wall is standard 3/8-inch drywall, primed twice and painted. The floor is 3/4-inch plywood, covered wall to wall with a loosely laid nylon carpet. Inside temperatures are maintained at about 70°F year round.

Author Mike Sherman is pictured in his laboratory, which houses the test room. This view, taken with a fisheye wide-angle lens, shows one of the insulated walls, the windows, and the external bank of lights.

Inside the test room, one of four temperature and humidity probes can be seen hanging from the ceiling. Location of the other three probes is indicated in the diagram below.



A diagram of the test room shows the location of four probes, which are attached to devices for monitoring variations in temperature and humidity. When charted, the variations indicate the insulation value of drapery fabrics and configurations.



This sketch of the manipulatable trough valance now being designed shows approximate dimensions. Both the top and bottom panels contain a series of holes. When the top panel is adjusted by means of a cord, similar to a drapery cord, the holes can be closed, partly opened, or completely opened to regulate the flow of air.

Allow me to present a new concept in energy-efficient air conditioning: panels of glass that can be raised — or lowered — by means of a handle fastened to the bottom of each panel. Now let me explain how the principle works

The room contains two double-hung windows installed side by side. Fourteen 100-watt light bulbs, each in a bowl reflector, are mounted on a panel outside the test room. The lights provide a source of radiated heat on the external surface of the window unit.

During the second stage of our research, we tested various drapery fabrics made of materials that are loosely and tightly woven, insulated and noninsulated, and lined and unlined. Length of the draperies remained constant while the effectiveness of several different positions for the support rod was tested.

During the third stage, now in preparation, we will study the windows as passive solar collectors and the best means of treating them to take full advantage of the heat exchange and convection principles.

Design of the collector relies on manipulatable trough valances placed above and below ordinary full-length, insulated draperies and the ability of the valance-drapery combination to capture or release heated air next to the window. When set in the insulating configuration, the draperies and valances trap hot air and thus prevent heat loss or gain inside the room. In the release phase, the manipulatable valance allows air to pass by the window air plane and enter the room.

During periods of heat gain (summer months), the valance will be tested for cooling efficiency when closed at the top and bottom while the windows are kept open above and below. During periods of heat loss (winter months), the valances will be open at the top and bottom to transfer hot air from the collector to the interior of the room. When outdoor temperatures are moderate, the draperies and windows can both be left open.

According to our research findings, window draperies can prove effective in slowing heat loss and heat gain in a room. We have reason to believe that, once tested, the trough valance described here will also provide an economical means of helping to heat and cool interior environments

Michael P. Sherman, assistant prof[illegible] of interior design

Shifting Populations in Illinois

Andrea H. Beller, John A. Quinn, and Andrew J. Sofranko

The best way to describe recent population trends for Illinois is in terms of something old and something new. What's "old" is the continued suburbanization around major urban centers, especially in the Chicago area, where the collar counties have growth rates ten times greater than the rest of the state. The "new" over the past ten years is the migration to rural areas, which had been losing people for decades. This dramatic departure from the past is being hailed as a rebirth or rural renaissance.

Several of the more important demographic changes in the state are captured in the following census findings from the last decade:

- Rural areas have grown twice as fast as urban areas or the state as a whole, with the more remote rural areas having even higher growth levels.
- Although population growth in Illinois stands at its lowest in decades, increases in the number of households have been substantial.
- Urban areas of the state are experiencing net out-migration, while the reverse is occurring in rural areas. This is a unique historical turnaround for Illinois.

The importance of these trends lies in the way they will affect the use of land, change the character of rural and urban areas, alter the provision of services, and perhaps ultimately affect the quality of life in both town and country.

Rural growth and urban stability. For the first time since at least the 1940s, population growth of rural areas exceeds that of urban areas. Urban counties are losing people through out-migration, much of it to rural parts of the state. This reversal represents much more than gains or losses in numbers. Individuals and families with particular characteristics, needs, backgrounds, and motivations are involved in the shift. As a result, both rural and urban areas are likely to experience changes that were largely unexpected. The influx of people into rural areas represents an opportunity for redressing problems associated with past out-migration, along with the challenge of accommodating the needs and expectations of new residents and firms seeking to locate outside of cities.

Large urban areas, too, will experience changes as a result of the continued shift of people outward to adjoining suburbs and the drift beyond them to rural areas. Urban population growth will be slowed, thus eliminating one source of problems that has beset cities in the past. However, decentralization will continue to be selective and, as a consequence, will continue to change the composition, character, and functions of cities.

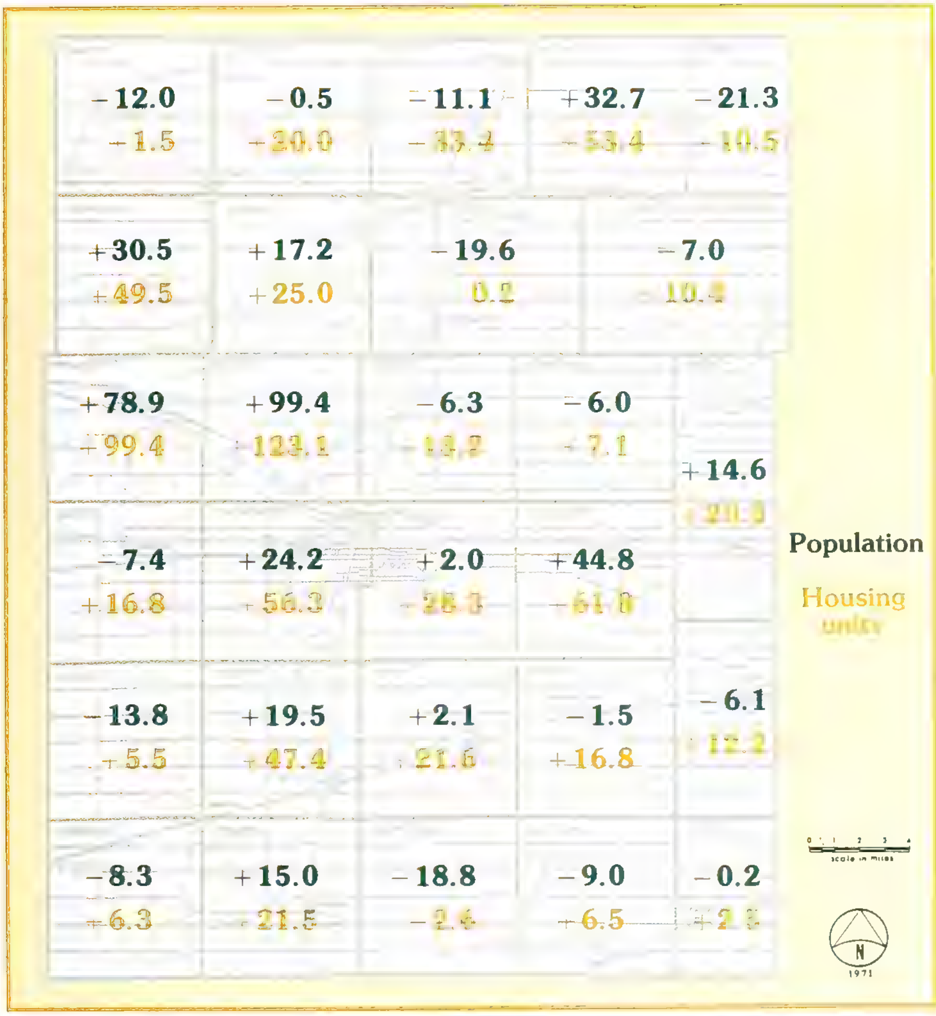
Rebirth of rural areas. Migration from the countryside to cities has been the dominant form of population movement in the state and nation. It is not surprising, then, that the recent population growth in rural areas has captured the attention of the public, the news media, and the government. In Illinois, rural counties have gone from net out-migration to net in-migration, while urban counties have experienced the reverse over the last decade. Explanations ranging from economics to attitudes have arisen to account for rural revitalization.

According to public opinion polls, Americans have always believed that the ideal residential community should be small, safe, clean, and near a large central city. Historically, however, we turned to the cities in search of improved earning opportunities and access to employment. Urban families were reluctant to indulge their taste for country living, because incomes in rural counties were so much lower than in urban counties (almost $2,500 lower in 1970).

But eventually some families have been able to make the move now that our society has become increasingly affluent. As incomes rise, people choose to spend less time working and more in leisure. The demand for recreational activities and facilities increases accordingly. Some families begin to feel the lure of the countryside, where travel through city traffic, waiting in line, and high fees are unnecessary to reach recreational facilities and where lakes, mountains, rivers, and wilderness areas are closer to home. Thus, the rising level of income is a push factor that allows people to move from urban to rural areas.

A pull factor is the improvement in transportation and communication. People now forgo less in moving to rural areas than previously. With improved transportation, for example, they still have access to large central cities. Moreover, advances in technology allow businesses to move away from urban centers. This increase in employment opportunities reduces the income losses associated with rural living. According to some data, while most individuals moving from large urban to rural areas experience a significant wage loss, the magnitude of the loss decreased during the 1970s. According to other data, the gap is narrowing between incomes in rural and urban locations, with incomes rising faster in rural areas.

The migration turnaround has also been helped along by the growing numbers of two-earner households



Map of Champaign County, Illinois, showing percentage changes in population and housing units by township between 1970 and 1980. Kerr Township lost a fifth of its population, while the population in Hensley Township almost doubled. Note that a decline in population is not necessarily accompanied by a decline in housing units. During the ten-year period, the population for the entire county increased by 3.1 percent and housing units by 27.6 percent. Champaign County provides an illustration of the growth differences occurring within Illinois counties.

(Base map courtesy of the Champaign County Regional Planning Commission)

and by increases in the number of people retired or anticipating retirement. In two-earner households, the second income may compensate if the main income suffers because of migration. Compared with other groups, retirees are the least concerned about employment. They lose little when moving and thus can afford to follow their preferences for rural living. During their working years, many of these families had acquired a second home to use on weekends and for vacations. These homes later became the primary residence, and the owners appear in the statistics as migrants.

It is too early to tell how this trend will be affected by the decline of real income caused by slow productivity growth and inflation, reductions in new housing starts, and generally depressed economic conditions. Whether the trend is temporary or will continue through the 1980s depends upon how well society deals with its economic problems.

Land use and population change. Along with the demographic movement, some changes were occurring in land use patterns in Illinois. Two major changes can be singled out: completion of the interstate highway system and development of large water areas. Two other changes should be noted: development of public parks and private tracts for vacation homes, as well as increases in surface mining of the state's mineral resources, with a concurrent shift in the use of agricultural land. One characteristic common to all these changes is that land use became more and more intensive, each successive use outbidding the former use in value.

While our focus is on population change, especially migration that produces a net increase, more is involved in changing land use than simply making room for new residents. In fact, communities may actually expand even when population declines, for example through shifts in the location of commercial activities or by the spreading out of existing populations (see map).

Settlement patterns are influenced by the total population, its distribution, and its characteristics. Generally our society can be characterized as highly mobile, with an affinity for areas having a low population density. But this affinity depends on a person's viewpoint. Someone from the city of Chicago might view the suburbs as desirable, whereas a suburban resident might have an eye on the small town of Sycamore farther to the west. The emerging shift of migration patterns would seem to be a response to a highly mobile population in search of more space than is now available to them.

Are the receiving counties in a position to accommodate population growth? Specifically, are the in-migrants still close enough to urban service areas or are they moving to rural nonurban locations that generally lack the common facilities and services expected by an increasingly affluent population? And how is agricultural versus nonagricultural land use being affected? In both of these situations, the problems and conflicts are more likely to be acute in the local counties but not nearly so critical at the state level.

Agriculture has been able to increase its productivity, in part because of technology and in part by shifting production on its own land base. But it's not clear how much more shifting of production can take place if the land base continues to shrink.

The issue of public facilities and services would appear to be more

immediate than the agricultural issue. As studies have shown, for every acre added to accommodate new residents, an average of almost one acre was added for other purposes, such as for businesses.

With the economy still in decline, both state and local governments are faced with a dilemma: meeting the demands for growth while financial resources are shrinking. In general, however, population growth has been received with favor. In this current situation, land use issues pose real challenges.

The future. It's difficult, of course, to speculate on the continuation of trends or the emergence of countertrends. Residential mobility will remain one of the hallmarks of American society, although current evidence suggests that residential change will occur less frequently than in the past. Whether the change continues in a decentralized direction or reverses itself as cities and economic conditions alter is unknown at present.

The rate of household growth is projected to drop off sharply after 1985, along with a moderating trend in many of the concomitants of such growth. There will probably also be a decline in many government-sponsored construction activities such as interstate highways, reservoirs, and lakes, which have altered the attractiveness of rural areas.

Against these more or less known changes stand the unknown responses of people to the differences between urban and rural living. Will they choose job opportunities over the quality of life and the environment? Will they opt for more space as opposed to access to a population center?

The trek back to the countryside during the past decade was stimulated by individual responses to these questions. At this point we cannot predict how people will respond to similar questions in making future migration decisions, but the responses will undoubtedly be important in where people choose to live.

Andrea H. Beller, assistant professor of family economics; John A. Quinn, associate professor of agricultural economics; Andrew J. Sofranko, professor of rural sociology

Communities — A Place To Be Human

William R. Nelson

Left to themselves, communities sometimes grow in a haphazard fashion. Through the Community Design and Visual Environment program, however, medium-sized cities and towns in Illinois have been able to obtain professional advice on how to go about making improvements. The goal of the program, which is sponsored by the Cooperative Extension Service, is to stimulate well planned, orderly growth while maintaining and enhancing the existing community landscape.

Put simply, a community landscape is the collection of buildings, streets, and spaces that we call cities or towns. It reflects the community's physical history, provides a tangible measure of today's activities, and is the resource of the future.

Enhancing the existing landscape is not a frill, but is an important commitment to accommodating people's needs and providing visual order. Likewise, new developments resulting from growth must be given thoughtful treatment so that they add to the community landscape rather than detract from it. When citizens understand these few principles, they can help exploit the full potential of their community by working with local government, businesses, developers, and citizen organizations.

Need for the program. The College of Agriculture has traditionally concerned itself with the quality of rural life and how it is affected by the physical environment of homes, rural towns, and small urban centers. In recent years this concern has intensified because the out-migration from major urban centers is putting economic and social stress on rural areas. The Cooperative Extension Service can draw upon specialists in the College of Agriculture to address problems that are related to shifting populations. In the long run, the state as a whole will benefit economically and socially from solutions to these problems.

Purpose of the program. The Community Design and Visual Environment program (CDVE) focuses on creating a suitable environment for people, hence its subtitle, "A Place To Be Human." We do not concentrate solely on physical structures and hardware, but rather look at the community as a place to live, to work, to shop, and to play. CDVE stresses the importance of accommodating people in redesigning the existing community landscape and in developing the new one.

The program also seeks to build a sense of cooperation among all sectors of the community. Our goal is not to spell out specific planning actions or to advocate specific organizational mechanisms for any of the communities enrolled in the program. We do, however, present options from which choices can be made. With alternatives laid out in front of them, communities can identify their own problems, both old and new. Once evaluated, appropriate options can be selected and translated into specific designs and courses of action.

In particular, CDVE explores vehicular circulation and traffic patterns; parking facilities; pedestrian movement and priority zones; and community improvement through landscape plantings, street furniture, lighting, signs, and other landscape amenities. Citizens are provided a basis for evaluating and discussing entryways, arterials, neighborhoods, parks, schools, churches, facilities for the elderly, and the central business district.

Trees help to relieve the drabness of parking lots, add architectural form to the space, channel the flow of traffic, and shade parked cars.

Trees connect a mobile home area into a residential environment providing shade, cohesiveness, and visual order.

Waterways that tend to invite the dumping of refuse can be transformed from eyesores into attractive public features.

Steps in the process. Communities that wish to participate in the CDVE program must request the service; they are not recruited. Experience has shown that voluntary participation reflects a level of commitment already present in the community. After enrolling in the program, the community moves through a series of four steps in assessing its needs.

Step 1. A color film is presented to help participants explore functional and visual problems of the typical community landscape. The film is designed to create an awareness of the problems and to build motivation for doing something about them.

Step 2. A dual slide presentation points out specific problems, along with alternative solutions. The slides are projected onto a double screen, one screen showing poorly designed parts of a community and the other screen showing well designed features. Several constructive solutions are suggested as options from which final choices can be made. Steps 1 and 2 are built around general or typical problems of Illinois communities.

Step 3. In this step, a videotape lecture focuses on specific problems faced by the particular community involved. Problem areas are captured by a portable video recorder. The tape is then presented to community leaders, with the Extension landscape architect providing clear-cut options for improving the situation.

Step 4. Organizing for action is the final step. When the community decides to tackle its landscape problems, it needs guidance in developing programs to deal with them. For example, it must plan ways of involving government, business, and civic leaders, as well as other concerned citizens and professionals. The community also needs to identify and determine the changes to be made. This step requires careful fieldwork and analysis of the findings in order to choose among workable alternatives and to avoid repeating mistakes of the past.

The Community Development and Visual Environment program uses county advisers and specialists in community resource development to follow up on the four-step program presented by the subject-matter specialist. In addition, a 300-page workbook has been prepared especially for local groups to help them progress through each stage of enhancing their community landscape.

Results and lessons. More than 200 Illinois communities have participated in the program. Of this number, approximately 150 have undertaken organized programs to bring about significant changes. Although the scale of each project has varied, the results have been spectacular. We have learned that once citizens become involved in establishing goals and gathering information, they can make better decisions and take a step towards accomplishing a place to be human.

William R. Nelson, Extension landscape architect

Trees in the Urban Environment

Jeffrey O. Dawson

Down through the centuries, plants have been used for food, medicine, clothing, housing, and fuel. From the hanging gardens of Babylon to contemporary American cities, plants have also been cultivated to help beautify our surroundings.

In many cities, trees are the most conspicuous form of vegetation. Growing along streets, on residential properties, and in parks, trees provide shade in summer, shelter from the wind and cold in winter, and channels for pedestrian traffic. Beautiful in themselves, trees can screen people from dust and from unpleasant sights, sounds, and smells.

When trees have to be removed because of decline or death, the wood is often processed into chips for landscape mulching or pulp production. Occasionally urban wood waste is also used as a fuel in some versatile power plants or given away as firewood in many small cities.

But trees can be a nuisance as well, at least for city engineers and those responsible for maintaining utility lines. When roots of certain water-seeking trees such as willows invade water mains or sewers, the conduits may eventually crack. Growing under streets and sidewalks, roots can lift and split the pavement.

Along roadways, low-branching trees sometimes obscure traffic signs and approaching vehicles at intersections. Around utility lines, fallen branches can disrupt service, and when weakened by decay, trees may be pitched over by a strong wind, making them hazardous to life and property.

Effective strategies for managing trees are therefore necessary to maximize the benefits and minimize the risks associated with trees that grow in urban areas. With proper management, community landscapes can be enhanced and the value of residential properties increased, sometimes by thousands of dollars.

As an aid to management, research

Trees improve the appearance of this industrial building, but may be planted too close to it to allow for maximum growth.

Planted as a shelterbelt, trees around a parking lot can effectively reduce wind speed and snow drifts in winter.

in tree selection, nutrition, and maintenance is being conducted at the University of Illinois. Guidelines developed from the findings can be obtained through the Cooperative Extension Service by individuals and municipalities, including those participating in the Community Design and Visual Environment program.

Trees for urban landscaping should be selected with certain characteristics in mind. For example, the species chosen must be able to tolerate urban and climatic conditions, should be easy to maintain, and must be able to grow at the soil pH, texture, and nutrient level provided. Moreover, the trees should be free of thorns, messy fruit, and other undesirable characteristics and should fit the functional and aesthetic purposes intended.

Much waste and expense can be avoided by selecting trees that can tolerate the low levels of soil oxygen associated with heavy clays or soils compacted by pedestrian and motor traffic. Suitable species for these conditions include green ash, sycamore, pin oak, and cypress, which are river-bottom trees found in Illinois forests.

Experiment Station scientists are now conducting basic research on the ability of some tree species to tolerate the low soil oxygen conditions caused by flooding, soil compaction, and paving. Under investigation are the physiological mechanisms that allow tree roots to maintain respiration with little soil oxygen. Our findings may one day lead to a laboratory screening method for identifying tolerant species without the necessity of lengthy field trials.

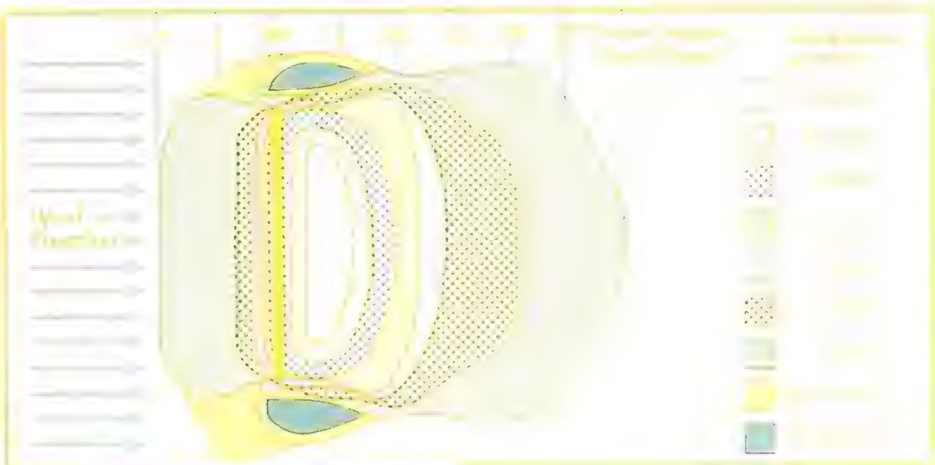
Energy-saving plans are increasingly being integrated with aesthetic goals in landscape plantings today. In recent studies of identical homes on similar sites in a temperate climate, the proper placement of a shelterbelt reduced the winter fuel consumption for one home by 33 percent. Windbreaks consisting of dense rows of evergreen trees can deflect wind over buildings and decrease heat loss. The appropriate placement of deciduous trees will reduce the radiant energy reaching a building when the trees are leafed out in summer. In winter when they are bare, sunshine will warm the structure. Thus the cost of cooling and heating a building can be reduced.

On construction sites, both public and private, the trunks of existing trees should be protected. Unfortunately, well intentioned contractors may be unaware that damage can also be caused by root compaction from heavy equipment and by grade changes. Furthermore, when soil is piled up under the crowns of trees, the roots may not be able to get enough oxygen. Some trees such as white oak are especially susceptible to oxygen starvation and may die several years after being damaged.

Municipal management of trees should include a strategy for planting several suitable tree species. In this way, the risk of losing the majority of a city's trees to a single disease or insect problem can be avoided. The destruction caused by Dutch elm disease in the 1960s should be a warning.

The management of trees in cities still needs much improvement. We tend to take trees for granted, but they will serve us best only if carefully selected for specific sites and purposes and for ease of maintenance and removal.

Jeffrey O. Dawson, associate professor of forestry



Plan of wind conditions near a moderately dense shelterbelt (adapted from Caborn, 1965). Wind speed is expressed as a percentage of the unobstructed wind. For example (**x**), at a distance 5 times the height of a 10-foot-tall windbreak, or 50 feet away from the trees on the protected side, wind speed is only about 40 percent of the speed on the unprotected side.

In Progress

Germ-free pigs aid in disease research

Some pigs in the College of Veterinary Medicine are used to clean living, so clean that their environment is without germs. The concept of germ-free animals goes back more than 70 years. Only within the last 10 to 20 years, however, has it been used to any extent in the study of diseases, according to Richard Meyer, professor of veterinary pathobiology.

Germ-free animals enable scientists to study the effect of a single agent on the host without complications from other agents. In every animal, including humans, a wide variety of microbes exists in the mouth and intestines, on the skin, and even in the fluid of the eye. By themselves, most of these microorganisms may be harmless.

Veterinarians are beginning to shed the long established notion that one disease means one pathogen. Although this concept applies to some diseases, certain others are caused by two or more microbes working together, as researchers are finding out.

Baby pigs are obtained by a hysterectomy and then reared inside a sterile chamber at the University of Illinois facility. Only a few other institutions in the United States have facilities for conducting similar germ-free research. Without this approach, Meyer said, researchers could not have progressed in their study of swine dysentery and coccidiosis, two major intestinal diseases afflicting pigs.

With germ-free pigs, Meyer and his colleagues have demonstrated that swine dysentery is a mixed infection caused by anaerobes and intestinal spirochetes. These findings are being used in an effort to develop a vaccine for the disease. The scientists are also using the germ-free animals to study the life cycle of the parasite associated with coccidiosis. Once this cycle is clarified, the researchers hope to identify the most effective drugs for treating the disease.

Veterinary pathobiologist Richard Meyer examines a baby pig in the germ-free rearing unit. Under sterile conditions, a disease-producing agent can be studied alone and in relation to other agents. Meyer and colleagues are currently trying to develop a vaccine for swine dysentery.

Fluoridation in the news again

The fluoridation of public water supplies is an emotional issue that arises periodically. Recently it surfaced again with reports of a severe shortage of the two chemicals most commonly used in fluoridation.

Adding fluoride to the public water supply to reduce tooth decay is required by law in Illinois and seven other states, but the practice also occurs elsewhere without mandate. In Illinois more than 90 percent of the population drinks from fluoridated water supplies.

Opponents of the practice claim that fluoridation has been linked to cancer, poor circulation, headaches, and chest pains. Proponents, including the American Academy of Pediatrics and the American Dental Association, won't swallow those claims.

"Fluoride is toxic in high levels, but it would be difficult to drink enough water to get an overdose of fluoride, because the kidneys do a good job of excreting it," said Terry Hatch, a physician at Carle Clinic in Urbana and a faculty member of the University of Illinois's Division of Nutritional Sciences.

"Fluoride is a trace mineral, but technically it is not essential in the same way as other nutrients," said Adria Sherman, assistant professor of foods and nutrition. "We could live and grow without it."

When ingested, fluoride is deposited in bones and teeth, making them stronger. In toothpaste, fluoride performs on the surface by killing bacteria. Recently, fluoride has been recommended for some adults as a treatment or preventative measure for osteoporosis, a degenerative bone disease.

Marcos Kogan, agricultural entomologist, displays leaf injury caused by insects.

Insect forecasts

Forecasting insect pest outbreaks is a new information tool that will help farmers control pests attacking their crops. Agricultural entomologists are working on a theoretical model that can predict the arrival of soybean pests such as bean leaf beetles, green cloverworms, spider mites, and grasshoppers. This monitoring technique can be applied to pests on other crops as well.

Data for temperatures, overwintering populations, spring arrival dates, and other factors are entered into a computer and then analyzed. Currently in operation, the model for the bean leaf beetle helped predict late outbreaks that caused heavy pod damage in 1980, said agricultural entomologist Marcos Kogan. Eventually there may be a statewide network, Kogan said. Once the necessary data have been entered into the computer, the model could begin operating for each region.

Kogan noted that this monitoring technique is compatible with integrated pest management (IPM), which is the selection of practices that will assure favorable economic, environmental, and social consequences with the use of appropriate cultural, biological, and chemical control measures.

Crushing machine for pesticide cans

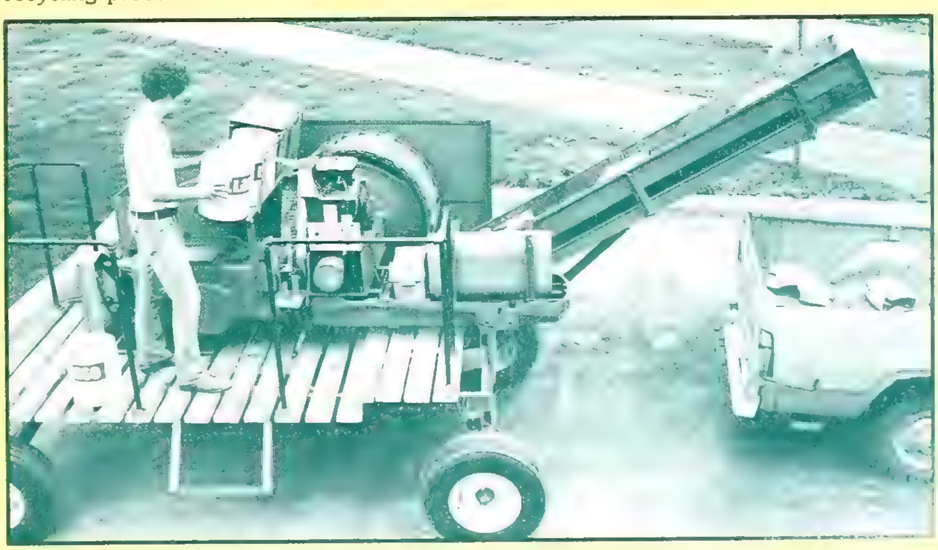
A can crusher being developed by agricultural engineers is one way of putting a dent in the problem of discarding empty pesticide containers. By law, farmers must triple rinse empty pesticide cans, but the regulations stop short of any directions for disposal.

Many containers are triple rinsed and reused for different purposes. Others are recycled, but some have been tossed into heaps along stream banks and other secluded areas. Powerful stuff, the residue in unrinsed containers is capable of affecting all types of plant growth.

Containers can be recycled by shipping them back to the steel mill in a tractor-trailer. But a semi-truck loaded with empty 5-gallon cans is an expensive and inefficient means of hauling a lot of air.

In search of ways to increase the number of cans per load, an agricultural engineering class at the University of Illinois designed and built a new crushing machine with funding from the Illinois Farm Bureau. The cans are crushed between two rollers driven by an 18-horsepower engine. After being crushed, the containers are dropped onto a conveyor belt and then loaded into trucks.

A student demonstrates the pesticide can-crushing machine designed by an agricultural engineering class. Disposal of empty containers has been a problem, but crushing them may simplify the recycling process.



Sweet sorghum fuel

Agricultural engineers have brewed alcohol from corn and squeezed oil from soybeans, sunflowers, peanuts, and sesame. Now University of Illinois scientists are about to start pumping fuel from sweet sorghum. The ethanol thus obtained, as well as vegetable oils and other organic fluids, can be used as an extender for petroleum fuels.

"Nature worked hard with corn and soybeans to put together a starch molecule that's good for food and feed, and it seems inefficient to break it down for fuel," said agricultural engineer Don Hunt. "It's fine to get fuel out of soybean oil or corn on a short-term basis for emergencies, but that shouldn't be the final answer," he said.

Compared with corn, sweet sorghum yields more alcohol per acre and is easier and less expensive to convert to alcohol. In crops like corn, wheat, and potatoes, an extra step is needed to convert starch to sugars before it can be turned into alcohol. But sweet sorghum juice is already a sugar solution and hence is one step closer to the fermentation vat.

Sweet sorghum usually competes for corn land, but Hunt believes that when corn is not in short supply, the sorghum crop could provide an alternative source of energy. Under test conditions, sweet sorghum is easily planted and harvested with minor adjustments to the technology used for corn production.

University of Illinois at Urbana-Champaign
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Illinois Research

Fall 1982

Interdependence of humans and animals

Illinois Research

College of Agriculture, University of Illinois at Urbana-Champaign, Volume 25, Number 1

1983 - Directions - 1993

Illinois Forests in Tomorrow's Economy

When picturing a typical Illinois landscape, one person might envision the Chicago skyline over Lake Michigan. Another might see rows of corn stretching to infinity in a prairie sunset. Probably one of the last things that comes to mind is a tall, stately forest. Yet such is the face of 4 million acres of Illinois land.

A public relations analyst would say that Illinois forests have an image problem. Although the state's forested acreage is greater than the entire land area of several northeastern states, our valuable forest resources remain largely unacknowledged, unmanaged, and underdeveloped. One of the challenges to Illinois is to [illegible] these forests and to develop marginal lands for future forests.

Illinois's neglect of its forest resources is understandable. More than 90 percent of the woodlands are in small holdings that belong to private, nonindustrial landowners who rarely appreciate the value and potential of their land. Reaching these landowners is critical if they are to become aware of the many uses for forest lands and forest products.

In these times of high transportation costs, it makes sense to use wood produced in Illinois. Wood products industries that are based in the state stand to gain, and the expansion of local markets will undoubtedly act as an economic incentive for many landowners to begin managing their forests. The economics of management and marketing will be high on our research agenda in the months ahead.

Timber production is one among several traditional options open to forest managers. Many experts in forestry predict that in years to come the Midwest will be called on to supply a greater portion of the nation's wood. As things stand now, Illinois ranks in the top ten states in wood use but in the bottom five in wood production.

In this issue of *Illinois Research* we look at research efforts designed to improve Illinois wood production. The primary focus, however, is on complementary and alternative uses of forest lands. The complementary benefits of forests include wildlife, aesthetics, fuel wood, recreation, and watershed preservation. We also emphasize forward-looking research on alternative silviculture for the production of woody biomass, integrated farming and forestry, and genetic selection for improved planting stock.

Through research and our communication and outreach efforts, we hope to [illegible] the ecological image of Illinois lands and to persuade landowners that wood is a choice agricultural product.

Gary L. Rolfe, head, *Department of Forestry*

The Cover

Trees pictured on the cover are part of the Illini Forest, a 40-acre tract on the South Farms at the University of Illinois. Started in the spring of 1951, the plantation now includes about 25 species of hardwoods and conifers. The project has a twofold purpose: first, to allow visitors to become familiar with various tree species and, second, to demonstrate how well these species perform on prairie soils. Among the species found in the Illini Forest are gum, walnut, oaks, red pine, white pine, and Norway spruce. The first trees were planted three decades ago by T.W. Curtin, J.J. Jokela, and R.W. Lorenz (emeritus), Department of Forestry.

Paul Hixson, *Illinois Research* photographer, took this photograph with a fisheye wide-angle lens.

"At a time unlike any in the past, we must envision the future."

Illinois Research

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Illinois Research

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To the editor:

Enclosed is a copy of my great², great², great², great², great² grandfather to accompany your Fall 1982 cover.

My father practiced in Rochelle 41 years. My still valid license to practice in Illinois is nearly 52 years old. Brother H. Neal is a University of Illinois graduate in agriculture; and brother-in-law Bruce W. Gilmore was a track team hurdler about 1925.

Lloyd D. Jones
Veterinarian
Winter Park, Florida

To the editor:

I would have expected *Ill* *search* to be committed t system. However, pages the Fall 1982 issue on A culture suggest otherwise

Daniel Gianola
Associate Professor of
Animal Breeding and Ge
University of Illinois
at Urbana-Champaign

The point is well taken. I alents will be included in sues. — Editor

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need to generate public support for basic research dealing with how domesticated animals perceive and deal with their environment, albeit difficult to determine and quantify the appropriate criteria. Expenditure of public funds in this way will do more to insure the future well-being of both man and animals than funding the enforcement of dubious legislation enacted on the basis of emotion and inadequate scientific information.

Keep up the good work and reporting!

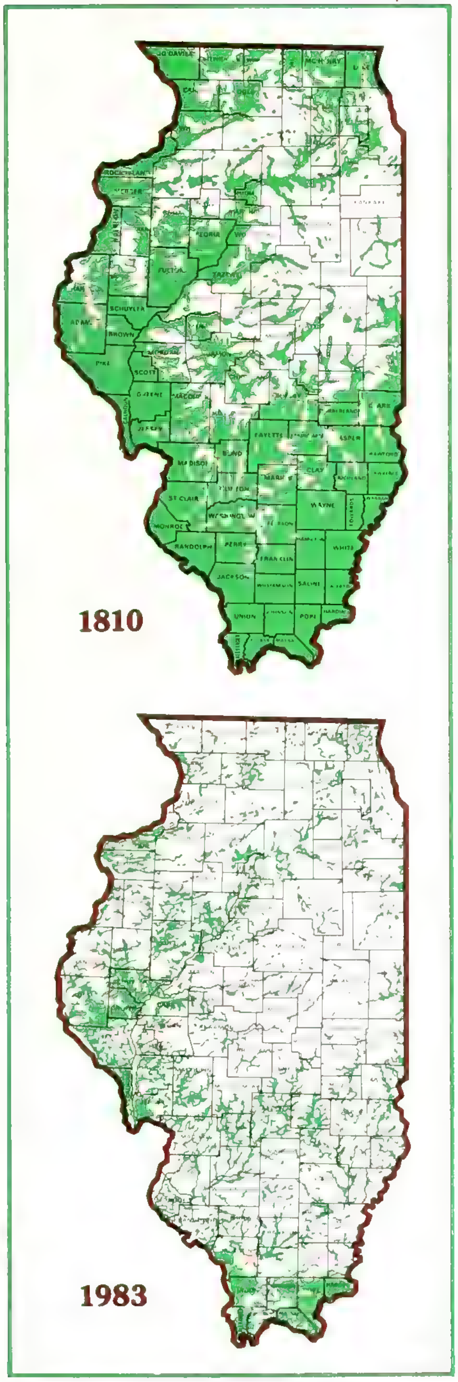
Donald J. Bray
Poultry Scientist
Cooperative State Research Service
United States Department of Agriculture

Birth of a calf from part of a limestone relief in an Egyptian tomb at Saqqâra, *circa* 2500 B.C. Other sections of the relief were pictured on the cover of *Illinois Research*, fall, 1982. Photo courtesy of Dr. Lloyd D. Jones.

Forestry and Land Use

Forestry in Illinois

Robert A. Herendeen and Gary L. Rolfe



Green areas show forest lands today and when Illinois was first settled.

Illinois is known as the Prairie State rather than the Sylvan State or the Nation's Woodbox; only 11 percent of the land is forested, compared with 30 percent for the rest of the United States. Despite this disadvantage, we believe that with improved management Illinois forests will become increasingly important to the state in the years ahead.

A century and a half ago forests covered 40 percent of Illinois. Today the remainder comprises 4 million acres, located primarily in southern Illinois and along the Illinois and the Mississippi Rivers. Hardwoods dominate, with 97 percent of the forests being classified as oak-hickory or elm-ash-cottonwood. Silver maple prevails on river bottomlands. Barely one percent of our forest land contains conifers.

Management problems. More than 90 percent of the 4 million acres is privately owned; the only major public holding is the 261,570 acres of the Shawnee National Forest. Private holdings are divided among 110,000 landowners, 37,000 of them farm owners who average 54 wooded acres each. The remaining 73,000 owners average 22 acres. Because of this pattern of many small holdings, improving the management of Illinois forests is extremely difficult.

Regardless of the inherent problems, we are determined to develop the valuable resource found on this poorly managed land. First, however, we must assess the potential of Illinois forests and identify some of the economic issues involved in realizing the potential. These matters, which were the subject of a recent conference held in Springfield, Illinois, are summarized in this article.

Potential value of Illinois forests. Modern forestry recognizes that forests can serve several purposes. They can be used to produce sawtimber, pulp logs, convertible biomass, and chemical feedstocks; protect soil and water quality; provide windbreaks, grazing lands, and recreational facilities; and offer aesthetic values. Some of these uses are compatible with one another and some are not. The value of any one use can be considerable; taken together, several uses add up to a still greater potential value.

If Illinois were to harvest the wood from its net annual growth, 86 million cubic feet of sawlogs could be produced per year. Converted to lumber, the harvest would amount to 520 million board feet, or enough to build about 50,000 new homes.

Given the quality of the land, this level of production represents only a third of the state's potential, according to data from the U.S. Forest Service. Compared with any of the other central and lake states, Illinois has a greater percentage of its forest land (40 percent) classified as highly productive, with a potential of at least 85 cubic feet per acre per year.

If converted to pulp instead, this output would provide roughly a fifth of the paper used in Illinois. Here again, the output could be tripled. Impressive as these figures are, Illinois is not likely to use valuable hardwoods for pulp in the near future.

Yields for biomass to produce energy can be significantly larger than yields for sawlogs, since rotations can be short and plantings dense. For example, the potential yield for sawlogs is 1.4 dry tons per acre per year (DTA), and 5 DTA for biomass for energy, according to our preliminary

findings.

Biomass crops can be fast-growing hardwoods like sycamore, autumn olive, black locust, and hybrid poplar, with rotations as short as 3 years. In some cases, coppicing, or resprouting from the stump, allows for several rotations before the rootstock must be replanted. At yields of 5 DTA, the biomass produced on 4 million acres could provide 9 percent of the total energy Illinois currently uses; even higher yields are possible.

The effect of forests on water quality is more difficult to quantify. To tackle the problem, we have been studying the interrelationship of forest cover, management practices, and water quality. So far our results indicate that the quality of water from forest watersheds is extremely good. We have also found that typical silvicultural and management practices for rotations of several decades have little effect on water quality.

Recreational and aesthetic values are an important area. One, perhaps imperfect, indicator is how often public lands in Illinois are used. People make about 800,000 visits annually to the Shawnee National Forest, 500,000 to state forests, and 32 million to county forest preserves. Most of the visits in this last category are to the Cook County Forest Preserves and include very short as well as longer stays. Measuring the value of amenities provided by private lands is more of a problem because access to them is often restricted. It is safe to say, however, that the value is considerable, especially near urban areas.

Because row crops are so productive on the rich soils of Illinois, the profits from silviculture must be measured against those from traditional agriculture. If environmental factors are included in the comparison, an increase of forested land is clearly needed. Three million acres now in row crops or pasture ought to be under permanent cover or in conservation use because of problems with soil erosion. If forested, these marginal lands — typically slopes or periodically flooded bottomlands — would help conserve topsoil and would roughly double the state's forest lands.

Introducing forestry to prime, rather than marginal, agricultural land is a controversial issue. As a first step, shelterbelts, once common but now quite rare, can be planted to enhance crop production, reduce erosion, and control snowdrifts so that soil moisture is distributed more uniformly. Shelterbelts also protect farm buildings and livestock and provide firewood.

Development of forestry. We feel that the limitations on forestry in Illinois are primarily economic rather than political or biological. A major stumbling block is the landownership pattern. To change the way land is used, we will have to cooperate with roughly 110,000 landowners.

Efforts among all the state and federal organizations involved with forestry in Illinois must be carefully coordinated. The University of Illinois and Southern Illinois University — the two state universities with forestry research and teaching programs — are working with the U.S. Forest Service, the Illinois Division of Forest Resources and Natural Heritage, the Soil Conservation Service, and other related organizations. Our own Department of Forestry in turn is working with other agricultural units in the College of Agriculture to ensure the integration of agriculture and forestry. Only through coordinated efforts will forestry in Illinois be fully developed.

Allan Mickelson of the Illinois Division of Forest Resources and Natural Heritage has pointed out that a typi-

cal tree crop, which might take 50 years to mature, annually yields a net of $10 per acre. In light of this low return coupled with tax increases and mounting pressures to develop land, it is no wonder that landowners either plant their woodlots to corn or leave them to the care of Mother Nature. The decision not to manage forests hinges on two main points: taxation of land and information on the returns from modern silviculture.

Illinois differs from surrounding states in that its land taxes do relatively little to encourage forestry. For example, Iowa, Missouri, and Indiana have reduced land taxes or impose only capital gains taxes on marketed timber. In Illinois under a new Farm Assessment Act (PA82-0121), forested land is assessed at no less than one-sixth of its lowest cropland value. The provision is a step in the right direction, but this level of assessment is still sometimes higher than previously and higher than in neighboring states.

Landowners must be educated, but to do so we need a reliable way of predicting individual benefits. The Department of Forestry is planning to develop a user-friendly package of information based on the economics of forest management. This information should eventually help landowners get a vivid picture of the costs and benefits of forestry on their sites.

Some neglected issues to be evaluated in the package include:

- *Competing land uses, particularly row cropping.* For example, if forests are converted to row crops, we will weigh the costs to producers for meeting the same water quality and soil erosion criteria now satisfied by current forestry practices. This information is especially important for bottomlands.
- *Rotation times.* Typical timber rotations of 30 years or more are longer than most private investors want to wait. But waiting times are shorter for several forestry options:

pulp	15 to 20 years
Christmas trees	7 to 12 years
woody biomass	3 to 7 years
firewood	10 to 20 years

Another option is integrated farming (interplanting row crops and trees), which offers inherent advantages as well as an early revenue. At the Dixon Springs Agricultural Center, we are experimenting with planting white pine at spacings of 40 to 60 feet within a row crop to assure a revenue for 10 to 12 years until the pine begins to shade the crop. In pastures, we are exploring methods for protecting seedlings and young trees from cattle.

- *Amenities provided by forests.* Especially in urban forestry, access and privilege need to be considered. Should communities financially support tree planting on private land, and how does the public view the costs and benefits?
- *Markets.* To manage their forests effectively, landowners must be well informed of the market situation and methods for marketing timber in Illinois. Part of the management package will show landowners how to exploit existing markets and evaluate possible new ones.

Illinois will probably never be dubbed anything but the Prairie State. But if we increase and coordinate our efforts, we believe that Illinois can dramatically improve its forests and will profit economically, ecologically, and aesthetically from them.

Robert A. Herendeen, assistant professor, and Gary L. Rolfe, professor, Department of Forestry

Early summer flooding in a bottomland forest after a heavy rainfall. Silver maples predominate along this stretch of the Sangamon River in east central Illinois.

Bottomland Hardwood Forests

Sandra L. Brown

Many forests in river floodplains stand on prime agricultural land. Understandably, the temptation to convert bottomland forests to row crop production is hard to resist. In Illinois alone more than 80 percent of these forests have been cleared and the land drained for agricultural purposes.

Sooner or later, however, many farmers run into problems with flooding, harvesting, and soil erosion. Crop loss is a stiff enough price to pay, but the problems don't end there. When bottomland forests are removed, wildlife, water quality, and other valuable resources often suffer.

Flooding. After the spring thaw, the streams and rivers of Illinois usually overflow their banks and flood the adjacent land. The water is silt ladened, carrying valuable topsoil, nutrients, and other chemicals from neighboring farmlands. Flooding in bottomland forests lasts a few weeks to as long as two or three months after a wet winter, but floodwaters are ordinarily down by early May. Later in the year, floods during periods of excessive rainfall usually last only a few days.

Most of our floodplains are dominated by silver maple, although willow, American elm, green ash, river birch, sycamore, and cottonwood are often present. In southern Illinois, stands of cypress and tupelo gum are also found in floodplains. Spring floods have little effect on these species because the growing season has not yet started. But once the season is under way, silver maple, river birch, cypress, and tupelo gum are more tolerant to longer periods of flooding than are the other species mentioned.

Species found in a given location are able to withstand the flood conditions characteristic of that area. In other words, the species are adapted to a predictable pattern of flooding. However, if the flood patterns are significantly altered, for example by channelizing or damming, the subsequent changes in the hydrology of the floodplain can have major effects on a forest.

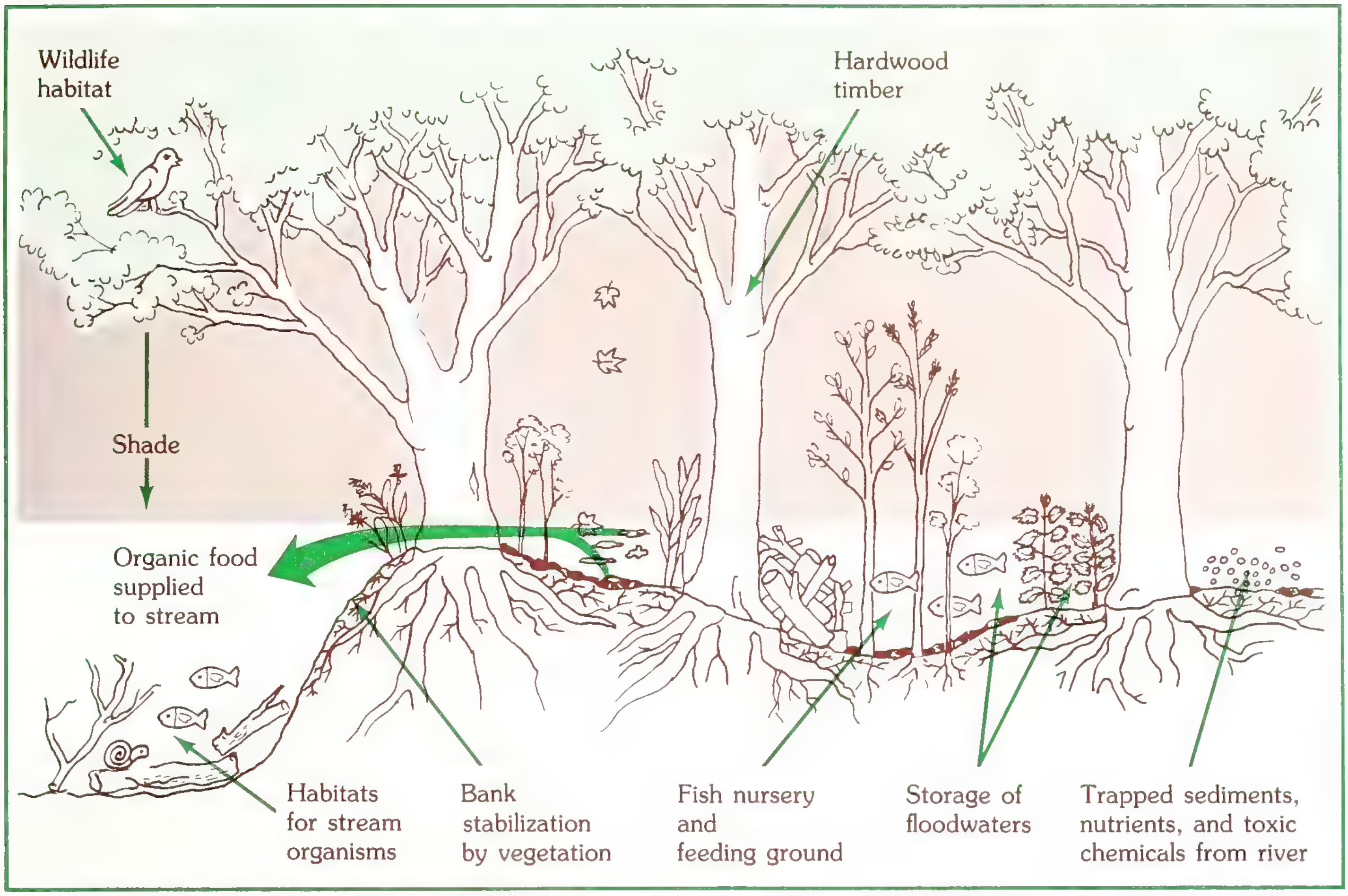
Services provided by forests. Fish thrive in streams bordered by forests because the trees are a rich source of organic food. They also deposit debris that fish use for protection and habitats. In addition, the shade helps to minimize fluctuations in the water temperature. During high water, bottomland forests serve as spawning grounds and nursery areas. In fact, many species of fish time their spawning to coincide with flooding. Deer, waterfowl, and other forms of wildlife also depend on bottomland forests for survival.

Forests improve the quality of water in adjacent streams by trapping substantial amounts of sediments and nutrients. When a stream overflows its banks, the water velocity decreases sharply. The sediment then drops to the forest floor and remains there after the waters recede. Removal of forests can alter this process and lead to the destruction of the nutrient-rich soils.

Streamside vegetation helps to stabilize river banks, thus preventing severe erosion along the river meanders. If carried downstream, heavy sediment loads can clog reservoirs and form hazardous sandbars in river channels.

A valuable means of flood control, bottomland forests store excess water during flood stage and release it as the stage drops. This natural control not only reduces flooding downstream, but also stabilizes river flow. Without bottomland forests, river communities run the risk of severe flooding, lose water supplies during dry periods, and spend more money building and maintaining flood control structures.

Finally, bottomland forests provide the raw material for wood products. Growing conditions are ideal for important timber species such as walnut, pin oak, sycamore, and cottonwood. Silver maples, which grow in almost pure stands in many bottomland areas, are also useful for timber.



Cross section of a bottomland forest showing the many services that forests provide.

Research in progress. Scientists in the Department of Forestry at the University of Illinois have determined that each acre of bottomland forest annually produces an average of 2 tons of fallen leaves and other small debris, which form the basis of the food chain in rivers and streams. Through the winter months, microorganisms decompose this organic material under the snow. Just before the floods in early spring, the material is richer in nitrogen than it was in the fall. During flooding, about half of the material is washed into the river, providing a nutritious source of food for aquatic organisms.

Other researchers have measured the rate at which sediments and associated nutrients are deposited in a bottomland forest along the Sangamon River, which drains an agricultural watershed. According to results from the first year of study, 17 tons of sediments were deposited on each acre of forest floor during the spring flood. This value is about one and a half times greater than the average erosion rate from the most highly erodible croplands in Illinois.

Along with these sediments, the river deposited 90 pounds of nitrogen, 11 pounds of phosphorus, and a total of 114 pounds of calcium, potassium, and magnesium per acre of bottomland. Clearly, bottomland areas can improve water quality by serving as sinks for non-point sources of pollution.

Effective management of bottomland forests for timber production is another important line of research. We have found that, where silver maples dominate, a stand tends to contain trees of about the same age. With even-aged management techniques, patches of trees in the same age class can be clear-cut, that is, harvested at one time. However, buffer strips should be left near river banks and in other sensitive areas.

Germination in bottomlands must also be understood if these forests are to be well managed. For example, thousands of seeds from the silver maple are disseminated during spring floods and can even germinate under water. As many as 13 seedlings per square foot have been counted after floodwaters recede, particularly in open areas where seedlings do well. While spring floods aid survival by providing the necessary soil moisture, summer floods can create havoc because of siltation and mechanical injury to the seedlings. Good management should therefore include planting seedlings that will be tall enough by summertime to keep their crowns above water. Seedling growth should be encouraged in open areas to avoid competition with mature trees. Studies of other important species, especially cottonwood, are in progress.

In another project, scientists in the Department of Forestry are measuring the growth of bottomland species in relation to the frequency and duration of flooding. Results of this research will help in developing predictive models for timber management.

We still don't know much about the potential advantages and disadvantages of converting bottomland forests to agriculture. To fill in the gap, we plan to compare the input and output of sediments, nutrients, and organic materials for both forested and agricultural bottomlands. A direct comparison will provide a sound basis on which to develop regulations for these areas. The information will also help landowners determine effective ways of managing their bottomlands.

Our work to date suggests that the best management alternative for these lands is to leave them forested. The short-term profits gained by converting them to row crops conflict with the long-term interests of the state, which must bear the cost of losing the "free" services provided by forests.

Once converted, however, how can these lands be reforested and still provide an income for the landowner? One possibility is by developing plantations for the production of short-rotation woody biomass. (See related articles in this issue of *Illinois Research*.) A return to traditional forestry has great potential as well, especially when rapidly growing species such as cottonwood and sycamore are planted. Better integration of agriculture with forestry on bottomlands may be yet another means of reducing the negative environmental effects of bottomland agriculture while continuing to generate an income.

The choice of a management plan for an area falls to the landowner, but the consequences are far reaching. We therefore need a comprehensive understanding and a detailed data base on which to weigh the pros and cons of bottomland forestry and agriculture. With this information we will be in a better position to make realistic decisions about the use of floodplains in Illinois.

Sandra L. Brown, assistant professor of forestry

Woodland Management

Theodore W. Curtin

Although their woodland acreage may be small, many landowners in Illinois have a valuable forest resource in their own backyard. With a little planning and effort, they could triple their wood production and at the same time enjoy the recreational, wildlife, and scenic benefits resulting from proper management. Like other crops, trees are living things that need some attention to enhance their health, beauty, and value.

Woodland management is neither particularly expensive nor difficult. Depending on their management objectives, owners can easily learn the necessary skills. When in doubt they can turn to Department of Conservation foresters for technical help in developing a management plan. But whether the land is put to work or not, taxes continue. Any income gained through careful management will therefore be to the owner's advantage.

Managing a woodland is similar to caring for field crops. Trees need to be planted to increase their numbers, thinned where necessary to aid development, and culled of undesirable specimens. The condition of the woodland will dictate these activities. Other management practices include pruning to increase the quality of the timber and harvesting the trees.

Unlike field crops, trees are perennial. Harvest schedules can therefore be adjusted to the fluctuations of the market once the owner has located outlets and determined the demand. Far from being an unpredictable bit of good fortune, timber can be cut and sold at a time of financial benefit to the owner.

When woodlands are left unmanaged, Mother Nature will care for them just as she does an untended lawn or garden. The trees will probably be far less valuable and attractive than if the owner had put even a little time into managing them.

Forest management is far less time consuming than taking care of livestock or field crops. What needs to be done and how much one chooses to do determine the amount of time spent on management. Usually scheduled at the owner's convenience, the work can be a rewarding weekend activity for the entire family.

Of course, growing a crop of trees involves the risk of injury from fire, windstorms, insects, diseases, and wildlife. The odds are not great, however, and many tree farmers are finding that their gains far exceed their losses. In fact, the risks are greater when owners do nothing with their woodlands. Without some management, the potential of the land is wasted, leaving the forest less productive, attractive, and satisfying.

Author Ted Curtin takes notes for developing a management plan.

Private, nonindustrial forest owners have a choice. If they decide not to improve their woodlands, natural deterioration is a real possibility. On the other hand, if they decide to expend the effort required, the property can be a source of enjoyment and profit.

Theodore W. Curtin, Extension forester

Home-Grown Firewood

Timothy A. White, Gary L. Rolfe, and Lester E. Arnold

The year is 1993. Efrem Brown stands in his barnyard as the autumn sun teases the shadows on his fields. His nearby grain bins overflow with the annual harvest. Farmer Brown is hoping that prices will stabilize for a change so that his income will be a little higher than expenditures for seed, fertilizer, and chemicals during the past season.

Special drying units on the bins will help him meet some of his expenses, because the wood chips that fuel the units come from short-rotation trees growing along drainage ditches, fencerows, and other areas of his farm. Four years ago he had planted the fast-growing trees during his spare time, and now they are paying off. Even after keeping enough chips this year to heat his home and farrowing unit and to dry the grain, Efrem had a surplus to sell at a tidy profit to the local elevator.

In his mind's eye, he follows the wood chips. Some of them are sold by the elevator to a power company and some to businesses that extract chemicals from the wood. Those chemicals, he knows, make good substitutes for petrochemicals, which are becoming more expensive every year. Efrem Brown smiles with satisfaction as he begins his chores.

Sound farfetched? Scientists in the Department of Forestry don't think so. In fact, we are currently doing research to make this scenario come true. In the foreseeable future, home-grown wood may very well replace many of the products from fossil fuels needed on the farm and elsewhere.

Biomass. Collectively, wood and certain other materials produced biologically are referred to as biomass. During photosynthesis, plants absorb carbon dioxide and through complex biochemical pathways ultimately convert it to simple sugars. These sugars in turn are used by the plant for energy or are converted and stored in plant tissues as cellulose, hemicelluloses, lignins, and other compounds. In the case of trees, the tissue is wood, which is one form of biomass.

Critical reactions of photosynthesis are driven by energy from the sun. Because plants convert and store solar energy as biomass, they can be thought of as living "energy collectors." In fact, fossil fuels owe their energy content to biomass production in past eons. The solar energy stored in plants can be released in a variety of ways to yield useful energy products such as heat, natural gas, alcohol, and steam.

Management of woody biomass. In 1978 researchers at the University of Illinois began to develop techniques for producing woody biomass as an energy crop in the Midwest (Fig. 1). Management of a biomass crop involves growing closely spaced trees and harvesting them frequently (Fig. 2). Currently we are studying several different spacings and harvest cycles (rotations) to determine the best combination for midwestern soils.

Trees planted at very high densities run out of growing space quickly and must be harvested sooner than trees that are spread farther apart. On the face of it, early harvest is to the owner's financial advantage. Unfortunately, as density increases, more seedlings are required, and the cost goes up. Our study will help to determine whether the profits realized from additional yields in dense plantings will offset the increased costs of establishment.

The species chosen for woody biomass production must grow well on marginal sites and have the ability to coppice — resprout from the stump — after each harvest (Fig. 3). Coppicing provides several harvests from a single planting, thus reducing establishment costs. Since many biomass plantations will be located on nutrient deficient sites, trees that can fix nitrogen are also a plus. These and other criteria suggest that species such as sycamore, autumn olive, black locust, European black alder, and hybrid poplar may be useful for biomass production.

Thus far, one-year-old seedlings have been used to establish biomass crops; however, this technique is very costly. Direct seeding as an inexpensive way of establishing plantations is now being investigated. Eventually, this method may be practical with ordinary farm equipment. For example, plateless corn planters might be used to seed black locust; field tests to date look promising. A combination of basic and applied research will help to determine the feasibility of direct seeding in biomass production.

Weed control is essential to the survival and early growth of trees, especially in a short-rotation biomass plantation. When biomass research began, we had very little information about chemicals for controlling weeds in plantations of hardwood seedlings. Since then, several herbicides have been identified and used successfully on particular biomass species. As a result, yields from experimental plots have increased greatly.

Yield. The yield potential of woody biomass grown in the Mid-

west is just becoming apparent. Up to 4 tons per acre have been produced annually from experimental plots of autumn olive, with only 15 centimeters of irrigation water and no fertilizer. Plots of black locust and sycamore have also yielded well. Coppice yields were measured for the first time in 1982, but results are not yet available.

Before woody biomass plantations become practical, we need to learn more about coppice yields, disease and insect resistance, environmental impacts on the site, and other problems unique to biomass production. Since woody biomass crops are perennial, the long-term stability of a plantation is important, but little is known about long-range productivity and the effects that high density forests have on the environment.

Traditional forestry has emphasized improvement of the aboveground parts of trees. For good coppice yields, we need to shift our attention to obtaining healthy, vigorous rootstocks and to developing practices that promote the well-being of roots under intensive cultural conditions. Clearly, we have a lot to learn before woody biomass crops can be recommended as a renewable source of energy.

Until some of these questions are resolved, individual landowners can reduce energy costs by exploiting their existing stands of hardwoods. Undesirable species, culls, and logging residues are already important sources of firewood, particularly in rural areas. By careful planning, a landowner can reap firewood and improve the quality of a stand for timber production and wildlife.

According to some estimates, as much as 14 percent of our national energy needs could be met by woody biomass grown on plantations. Regionally, this figure could be even higher. Through research at the University of Illinois and at other sites across the nation, the farm of Efrem Brown may one day become a reality.

Timothy A. White, associate forester; Gary L. Rolfe, professor; and Lester E. Arnold, forester, Department of Forestry

Fig. 1. Forestry researchers are evaluating biomass productivity at several sites across the state. This aerial photograph shows biomass research plots at the Dixon Springs Agricultural Center in southern Illinois.

Fig. 2. Woody biomass research involves measuring growth and vitality of many hardwood species under a variety of conditions. Author Tim White is shown here in a plot of autumn olive, one of the most productive species among those tested.

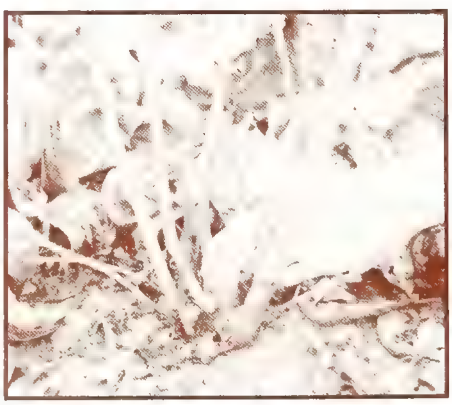


Fig. 3. Hardwood species can resprout from the stump after harvest. Wood can thus be harvested several times from a single planting, lowering the cost of biomass production.

Chemicals, Fiber, and Energy From Woody Biomass

Poo Chow, Gary L. Rolfe, and Lester E. Arnold

Trees may one day help the United States find a way around the rising cost and decreasing supply of fossil fuels and fossil-based chemical feedstocks. In efforts to reach this goal, we are now investigating the chemical and fuel values of several tree species, especially those that can be grown in short rotations. We are also searching for ways to use fast-growing trees to produce raw materials for paper and building board.

Wood is a complex organic substance whose chemical components profoundly influence the way it is used. The components vary widely with the species and the part of the tree in question. For example, species with a high cellulose content may be suitable for paper and building boards. Other species with a high content of alpha-cellulose and extractive materials may be suitable for the production of chemicals. (Alpha-cellulose is used in the manufacture of nylon and photographic film.)

Chemical feedstock. Basic information on the chemical behavior of high yielding, plantation-grown trees is needed before we can determine the economic advantages and disadvantages of converting biomass to energy and chemical products. This information will add to what we already know about the composition of most woody plants and of materials extracted from them (Fig. 1). In living trees, chemical extractives serve mainly as food reserves of fat, fatty acid, sugars, and starch; protecting agents such as terpenes, resin acid, and phenols; and plant hormones.

All of these substances can be extracted with solvents that fall into three categories:

- hot water — removes inorganic salts, oligosaccharides, sugars, cycloses, cyclitols, and phenolic substances
- one percent solution of sodium hydroxide — removes fatty acid, wax, resin, essential oil, and hemicellulose, which contains wood sugar
- alcohol-benzene — removes certain phenolic substances such as sterols and tannins; some organic acids such as resin acid and amino acid; and other materials including pigments

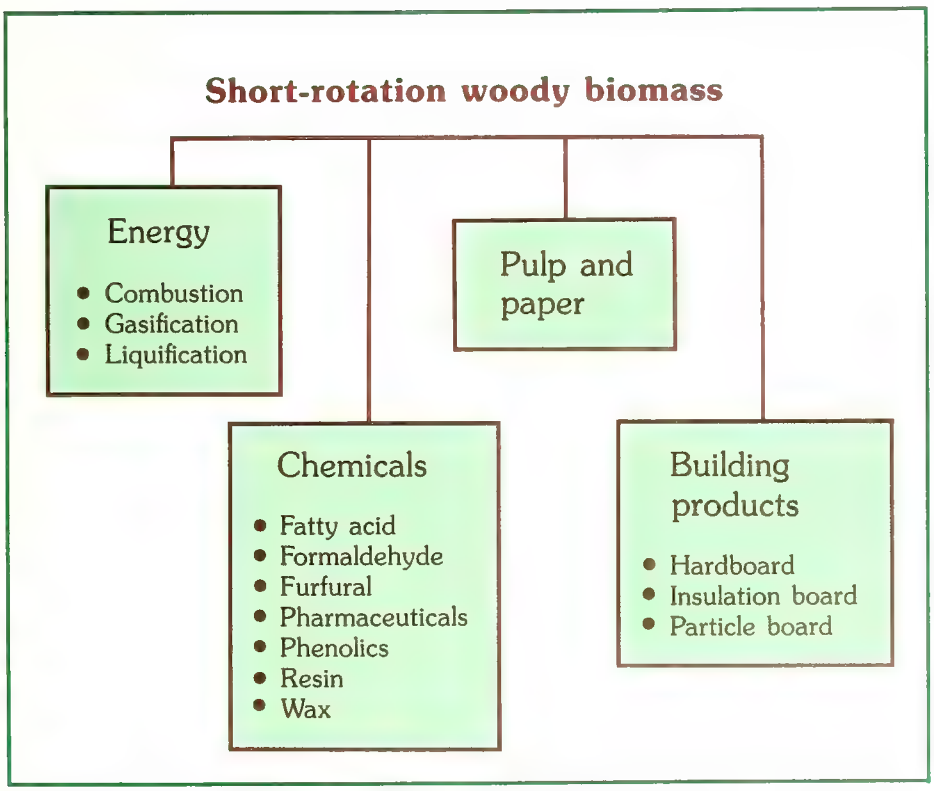


Fig. 1. Biomass from trees grown in short rotations is a source of many products, including chemical feedstocks. Phenolics are used in the manufacture of adhesives, fungicides, and plastics. Furfural is used in making industrial solvents.

Fifteen to 20 percent of fuel wood produced in the United States is used to heat homes and small industrial and commercial buildings.

In his laboratory, Poo Chow extracts chemicals from fast-growing hardwoods, which yield phenolics, wax, oil, organic acids, and other chemicals.

Prototype of a wood combustion furnace, shown here in front of a grain storage bin, converts biomass to heat for grain-drying and space-heating experiments.

Paper and board. By the year 2020 the demand for paper and board products such as hardboard, insulation board, and particle board will probably double, according to estimates made by the U.S. Forest Service. Spurred on by the increasing, widespread shortage of raw material for these products, we are now exploring new sources of fiber from short-rotation trees.

Direct combustion. As a source of energy, wood can be used most efficiently by burning it directly, an activity as old as the human race. About half of all the wood harvested worldwide is used for fuel by direct combustion. Today, wood provides 2 to 3 percent of the nation's energy, compared with about 5 percent from hydroelectric power and 7 percent from nuclear sources.

Of all the wood used for energy in the United States, 80 to 85 percent supplies heat for industrial processes. Except for a tiny percentage, the remainder is used to heat homes and small industrial and commercial buildings. Most of the wood is burned directly or in the form of black liquor from kraft pulping in paper mills. Small amounts are converted to charcoal and to densified pellets and briquettes.

Biomass research. No two tree species contain the same level of chemicals. Even the same species at various ages will differ somewhat in chemical content. So that trees can be used to best advantage, we have analyzed the composition of seven deciduous species: autumn olive, black alder, black locust, eastern cottonwood, royal paulownia, silver maple, and sycamore.

Samples of each species were collected in bundles from bottomland plots at the Dixon Springs Agricultural Center in southern Illinois. All samples were taken from two-year-old trees, the trunks of which are about 2 inches in diameter. Six randomly selected trees from each bundle were air dried, ground up in a Wiley mill, and the particles passed through screens. The particles were then oven dried at 220°F. Commercial lumber from mature trees was

used for comparison with the juvenile trees (Fig. 2).

Six tests were run on each of these materials. Using the three solvents discussed earlier, we found that the percentage of extractives was significantly higher for juvenile trees than for the commercial lumber, regardless of species. Similarly, the percentages of ash, sulfur, holocellulose (cellulose after the extractives and lignin are removed), and pentosan were also higher in the young trees. In contrast, juvenile wood had a lower lignin content than did the lumber. The percentages of heat and alpha-cellulose were also slightly lower, but not significantly so.

Compared with commercial Illinois coal, juvenile wood from all seven species contains considerably less ash and sulfur and is therefore a much cleaner fuel. When burned directly, 1.5 tons of dry, short-rotation wood yields about the same amount of heat as one ton of commercial coal (Fig. 2).

In a long-term research project, the Department of Forestry is conducting an on-the-farm study of a furnace for converting biomass from plants to heat energy. A prototype of a small-scale wood furnace was installed and is now being monitored. The purpose of the project is to determine the feasibility of using this biofuel system to dry grain and to heat homes. Energy gains and fuel efficiency, as well as the time and labor required to operate the furnace, are being evaluated.

The benefits to be gained from forestry in Illinois look promising. As our research findings indicate thus far, good quality fuel, fiber, and chemicals can be obtained from hardwood species grown under intensive care on marginal Illinois lands. The chemical industry in particular will find it advantageous to turn to woody biomass as a source of organic chemicals with the deepening shortage of petroleum by-products.

Poo Chow, professor; Gary L. Rolfe, professor; and Lester E. Arnold, forester, Department of Forestry

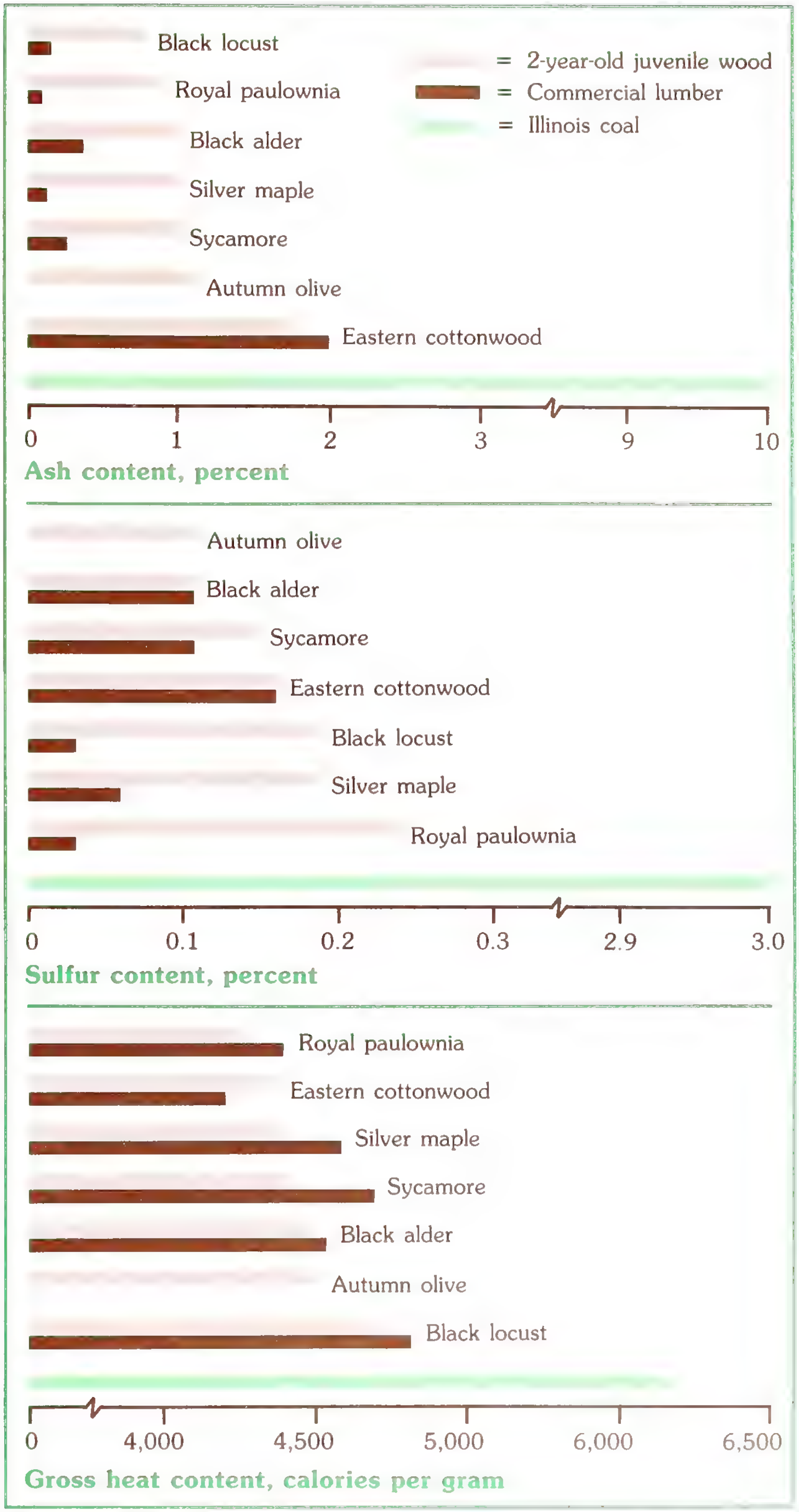


Fig. 2. Low in ash and sulfur, wood from juvenile trees is a cleaner fuel than Illinois coal. About 1.5 tons of juvenile wood provides as much heat as 1 ton of coal.

Breeding Forest Trees

Jalmer J. Jokela

Anyone who cuts down or plants trees in a forest is automatically selecting parents for the next generation. Over time, if only the largest and finest trees are removed, the outcome is predictable: subsequent generations will spring from the inferior trees left standing and the forest will slowly degenerate. Decline will be just as sure if trees of unadapted seed origin are planted.

Long before the rediscovery of Mendel's work in 1900, hereditary differences within a tree species were recognized. As early as 1820, a French plant breeder by the name of de Vilmorin studied geographic variation using a racial test of Scots pine. And a few years before the middle of the 19th century, systematic cross breeding of tree species was undertaken to increase their vigor and rate of growth.

Although scientific breeding of forest trees was advocated in the early 1900s, improvement was not earnestly begun until shortly after World War II, when reforestation programs were expanded. Because planting trees was expensive, superior seedlings for short rotations were in demand. Improvement programs therefore became a necessary adjunct to reforestation. Progress in developing fast-growing, pest-resistant trees must continue if we are to prevent serious wood shortages in the coming century.

Geographic variation. Climatic and site conditions vary within the usually large botanical ranges of tree species. Geographic variation in the species reflects adaptation to these environmental differences. Studies of geographic variation are necessary to identify the best sources of seed for native and introduced tree species and to provide breeding materials. Trees selected for one region may not thrive in another. Scientists have found considerable variation in almost every species studied. Understandably, foresters don't want to risk planting trees of unknown or untested seed origin.

These findings can be applied to shade and landscape trees as well. Without knowing where seed has come from, buyers and suppliers may unwittingly obtain trees that are ill-adapted to an area.

Cooperative studies. Since 1960 the Illinois Agricultural Experiment Station has conducted seed source and breeding research with other stations cooperating in the North Central Regional Tree Improvement Project. Some of the findings from this work are summarized here.

Scots pine seed used in this study represent the entire natural range of sources from the British Isles to eastern Siberia and from the Mediterranean to the Arctic. As expected, variation is extensive in this widely distributed species. In winter the color of the foliage varies from the dark green of trees from southern origins to the golden yellow of trees from extreme northern origins. Trees from the north are the slowest growing, while those from central Europe grow the fastest and have

The tree being measured by author Joe Jokela is an eastern cottonwood clone at 15 years of age. At age 20 this tree had produced enough wood for one cord of pulpwood (or fuel wood) or 500 board feet of sawtimber. The cottonwood clones shown here were raised in the Sangamon Forest Plantation, Piatt County, Illinois.

the longest needles. Using this information, Christmas tree growers can select varieties for color, needle length, winter hardiness, growth rate, and form. Scots pine does not seem to have much value for timber in Illinois.

Eastern white pine from Appalachian seed sources is hardy in the southern part of our region and grows considerably faster than trees from northern sources. We are now trying to pinpoint the best southern Appalachian sources of seed for use in southern Illinois. These trees are expected to grow better than any other pine on many sites in that part of the state. Seed from the central part of the botanical range seems best suited for northern Illinois.

Douglas fir, a preferred species for windbreaks and Christmas trees in Illinois, usually takes 14 or 15 years to grow to appropriate size. But in the Douglas fir study an interesting fact came to light: trees from seed sources at high elevations in Arizona and New Mexico grow to Christmas tree size in only 8 or 9 years. They are also winter hardy.

Japanese larch is native to central Honshu, one of the Japanese islands. Because of the small natural range, trees from this source show little variation. Performance in test plantings suggests that Japanese larch has great potential as a timber and landscape tree in Illinois.

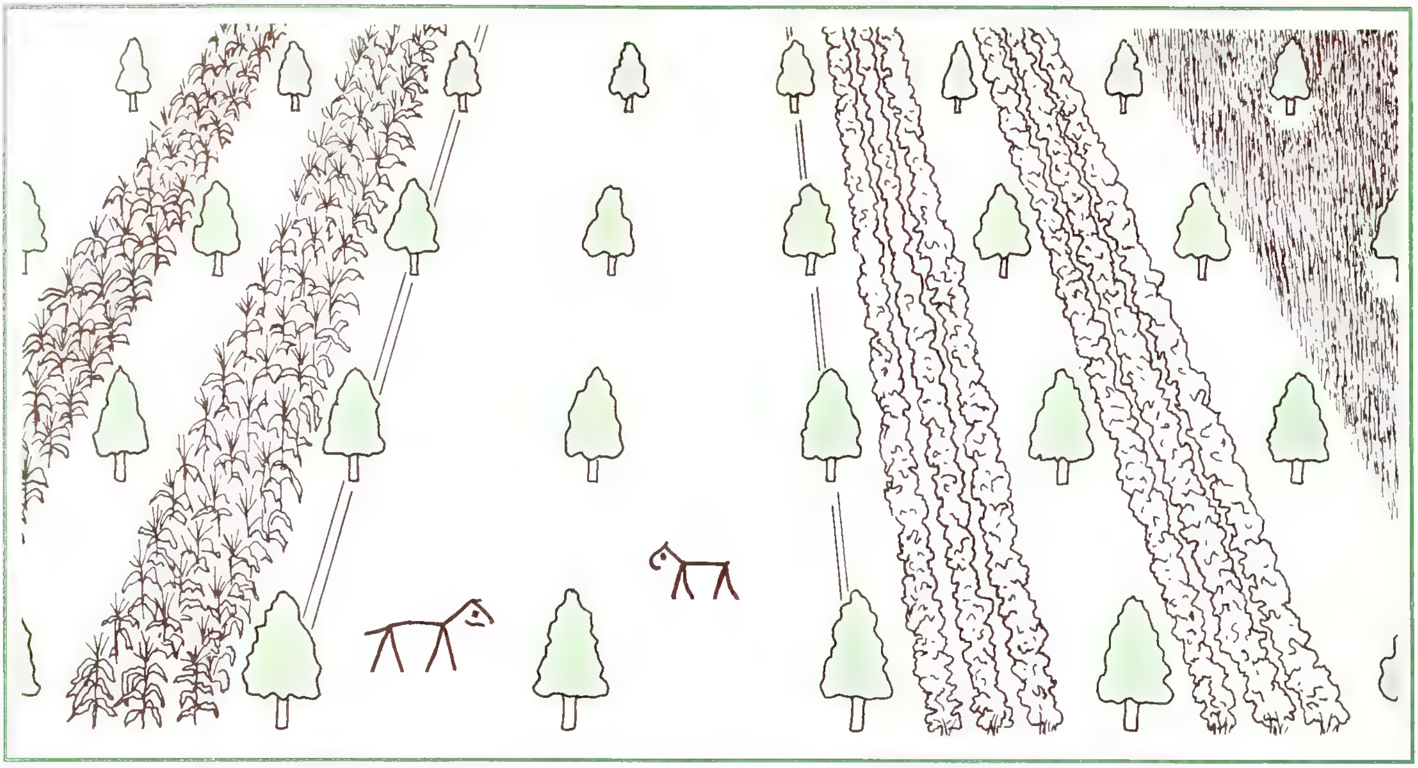
Poplar culture. Eastern cottonwood promises to become a great wood producer in Illinois, where it occurs naturally on well drained bottomlands. Its growth surpasses that of any other native species. Cottonwood also thrives on moist, well drained upland sites. Even though it does poorly on mine spoils, it grows faster there than any other naturally seeded species. Cottonwood will probably contribute most to timber production when raised in well managed, short-rotation plantations.

Wild cottonwoods growing in stands have too many pest and growth problems to warrant intensive culture at wide spacings. The cumulative effect of annual leaf-rust infections alone can result in unacceptable losses. In one study, the 15-year yield of susceptible trees was less than one-third of the yield from highly rust-resistant trees grown in a central Illinois plantation.

Europeans practice intensive poplar culture using pest-resistant, fast-growing clones specifically selected for each planting site. In Illinois the development of such clones has been emphasized during the past decade, and select clones are now ready to be released for planting in the southern and central parts of the state. Sawlog production from clones raised in rotations of 20 to 30 years on good land is expected to average more than 2,000 board feet annually, or ten times the yield obtained from a typical woodland.

In rotations of 10 to 15 years, these clones are able to produce more than five cords of pulpwood or fuel per acre each year. At this rate of growth, poplar clones raised on 2 or 3 acres could supply all of the wood to heat an average home. Annual cash savings could exceed $500 on natural gas and $1,000 on fuel oil. Cultivating poplars on flood banks, bottomlands, wet areas, or odd-shaped lots may one day be a wise and profitable use of land.

Jalmer J. Jokela, associate professor of forestry



Example of a fully integrated farming and forestry enterprise. While the trees are becoming established, the land can be use for row crops, forages, and grazing.

Agroforestry

Lester E. Arnold and Clarence J. Kaiser

Agroforestry, or integrated farming and forestry, is not a new idea. To a limited degree it has been practiced for generations in the United States. Grazing of pine plantations in the south and southeast and of partly forested, mountainous country in the west are two examples. Some grazing also occurs in pecan or black walnut orchards and occasionally in apple or peach orchards.

Orchard grazing is usually considered incidental to production of the fruit crop; consequently, few data are available to evaluate the practice. However, most orchard owners, especially those who raise livestock as part of their farm operation, count the forage from their orchards as an excellent bonus. Grazing also helps keep orchards clean. Cash-grain cropping of forest plantations is rare.

Research under way. Grazing and cash-grain cropping among trees managed for various uses are now being examined. In 1982 the Illinois Agricultural Experiment Station provided pilot funding for a research and demonstration program. The objectives are to develop economically and ecologically sound cultural systems that will maximize the use of land by integrating farming and forestry.

Within the past decade the public has become increasingly aware of the problems related to intensive cash-grain cropping (Public Law No. 92-500, Section 208). We believe that the soil erosion problems resulting from farming can be eased by introducing foresty into existing agricultural systems.

Agroforestry can be practiced in two distinct ways. First, it can be a fully integrated enterprise in which the trees produced are as important as the crops or livestock. Marginal lands are well suited to this use. Rows of trees, spaced 35 to 65 feet apart, stabilize the soil and at the same time provide biofuel, Christmas trees, nuts, high quality lumber, and veneer. Second, agroforestry as a supplementary use of land can provide windbreaks, erosion control, biofuel, and wildlife habitats. In this case the trees are periodically spaced along continuous strips in prairie areas.

Under what circumstances might farming and forestry be practical on the same piece of land? To answer the question, researchers will study various combinations of fruit, wood, and fiber production when integrated with grain crops and forages as well as with cattle and sheep grazing. We will also evaluate fiber for conversion to energy. Several tree species and planting densities will be taken into consideration.

Specific aspects of the integrated systems to be evaluated include:

- livestock grazing, crop production, or both in existing plantations of black walnut, pecan, white pine, and yellow poplar
- pesticides needed for managing the systems under development
- grain crops and forages that are

compatible with the overstory trees

- production of biomass for energy from nitrogen-fixing autumn olive, black alder, and black locust
- nut and wood yield of black walnut integrated at various densities with crop production and livestock grazing

As funding and technology permit, we will study honey locust for wood yield and the pods as an energy source and livestock feed; pecan for nut and wood yield; and white pine, yellow poplar, and paulownia for wood yield. Throughout all of these projects, two controls will be maintained: conventional open ground for farming and livestock grazing and a conventionally protected forest plantation.

During the first few years, row crops will be planted between the rows of trees. Some trees will be protected until they are tall enough not to be damaged by grazing. A 6-row, zero-till corn planter and a 15-foot drill with room for one pass will provide the spacing framework. Initially, 5 feet for buffer clearance will also be maintained for each row of trees. Trial spacings will include 20, 35, 50, and 65 feet between rows.

We are investigating a wide range of management schemes, from the very intensive management of black walnut for nut and timber products plus intercropping to the only slightly more extensive management of white pine and wildlife. Our findings should be applicable to many different conditions. As energy costs increase, several of the systems considered could well produce the best mix for soil conservation, grain production, livestock grazing, wood products, and feedstock or edible nut production. With these options, land managers should be able to maximize their net returns over time.

Agroforestry may one day be reasonably competitive with some of the systems that now require large amounts of fossil fuel. The current and anticipated needs for liquid fuel suggest that landowners may well find it profitable and certainly ecologically sound to manage various soil conditions with some form of integrated farming and forestry, especially on highly erodible upland soils.

A compromise? This program proposes a compromise between farming and forestry on marginal lands. If the program works, we can look for increased net returns over time from either agriculture or forestry or, almost certainly, from a combination of both systems. Improved returns are especially critical, given the recent increases in energy costs associated with farming and forestry.

Farmers and foresters alike face similar soil-related problems. When preparing a site for row crops or tree plantings, for example, they must anticipate potential problems with soil erosion, nutrient losses, and soil moisture. Both also aim for net capital returns on the time and money invested, but with somewhat different expectations. Farmers expect a quick return of 3 to 36 months on their relatively large investment. Foresters, on the other hand, invest modestly and expect a return only after 5 to 50 years.

When terrain and soil permit, it makes sense to plant a row of white pine, for instance, leave a strip of tillable ground 30 feet wide, plant another row of pine, and so on. For the first 8 or 10 years, more than 90 percent of a field can still be used to grow row crops while the pine becomes established. Farm machines don't pose a problem because the stems of trees that are raised as a wood crop extend well above the zone of clearance. Once the trees have grown to a height of 10 or 12 feet, controlled livestock grazing can be allowed. By 20 years of age, the stems of most trees can be pruned to a height of 17 feet without reducing their growth.

Trees planted in continuous strips serve as windbreaks and help control erosion.

Pruning will be necessary to obtain high quality saw timber and veneer logs. White pine in particular must be pruned until it begins pruning itself naturally at about 90 years of age. Because of the open nature of plantations, new seedlings can be planted successfully — but of course must be protected from livestock — for a number of years in areas of poor survival.

The pressure of livestock grazing in a stand of young pine eliminates the need for prescribed burning and probably prevents honeysuckle from becoming a problem. Since the stands are dispersed, insect populations should not be a major problem. If necessary, conventional spray equipment for orchards can be used until the trees are 20 to 25 feet tall.

Applied ecology. Black walnut is preferred on well drained bottomlands or alluvial soils and on moist, grassy waterways. An advantage of black walnut, expecially on valuable sites, is that the crown is not dense, thus allowing many forage grasses to grow beneath the canopy. Honey locust has the same characteristic.

By manipulating tree spacings and the use of land between rows, a manager can shift the emphasis from classical tree farming to cash-grain crops (corn and beans) and livestock grazing. Both systems have distinct advantages and disadvantages. Maximizing the advantages by integrating the two systems is the purpose of our research.

No two species require exactly the same growing conditions; in fact some species interact to improve conditions for each other. This observation follows from the basic ecological principle that a site can be more effectively utilized by two or more species than by a single species. Intensive use of each acre is the key to making agriculture and forestry compatible.

Lester E. Arnold, forester; and Clarence J. Kaiser, associate professor of agronomy at the Dixon Springs Agricultural Center

Urban Forestry

Jeffrey O. Dawson

A discussion of forestry in Illinois would be less than complete if urban forests and foresters were left out of the picture. Although few city dwellers may realize it, recreational areas and the forested watersheds that supply municipal reservoirs are managed by foresters. Other areas under their management include forested land on military bases, arboreta, greenbelts, and wildlife refuges.

As consultants, foresters advise industry, municipalities, and landowners. Foresters also work with arborists, horticulturists, landscape architects, plant pathologists, entomologists, and other professionals. Together they inventory, plant, and maintain ornamental trees in cities. Management of urban forest preserves is perhaps a forester's most conspicuous contribution to urban areas in Illinois.

Forest preserves. Authorized by the Illinois State Legislature in 1913, the Cook County Forest Preserve System was organized as a Forest Preserve District in 1915. It now consists of about 65,000 acres of forested lands dedicated as natural sanctuaries for the education, pleasure, and recreation of the public (see box).

Part of a team that manages the system, foresters run a tree nursery to provide planting stock for reforestation of district land. Other responsibilities include monitoring and controlling disease, insect, and animal pests. Neighboring DuPage County has a similar forest preserve system.

Watershed stabilization. East of the Mississippi River, 12 million acres of forest lands protect watersheds and the shorelines of reservoirs serving some 750 municipalities, as E.S. Corbett found in a 1970 survey. Many of these municipalities employ foresters who, by maintaining watershed forests in a vigorous and pest-free condition, ensure that clean water will reach the reservoirs. Forest managers regulate harvesting and recreational activities along reservoir banks and stream margins to prevent soil from eroding into the water supply.

Foresters can influence water quantity as well as quality. Under the right conditions, a single tree such as a large oak can release more than 100 gallons of water per day to the atmosphere through evapotranspiration. During this process, water pulled from the soil through the tree's vessels evaporates through the leaves. When some of these trees are harvested, more water can percolate into the soil and recharge streams. Annual water yields in stream outflow can thus be increased significantly.

Researchers in Michigan have shown that changing the composition of forests from conifer to hardwood has a similar effect on water yields. Because conifers retain their foliage, evapotranspiration takes place throughout much of the year. In contrast, the process stops in broad-leaved deciduous hardwoods when they drop their foliage in autumn.

Urban wastewater processing. Because cities that are extensively paved are essentially waterproof, rainfall is quickly shed and often taxes the capacity of storm sewers. But forests in and near cities can provide a natural remedy for the problem. Forests have extensive root systems that bind soil and create channels for infiltration as some of the roots die each year. The humus and litter accumulated by forests hold precipitation and harbor organisms that loosen the soil through their burrowing activities. Thus forest ecosystems in the temperate zone can accept large amounts of rainfall without surface runoff. In addition, forests along discharge streams aid in the infiltration of water and help to stabilize the banks of waterways in urban areas.

Forests have also been used experimentally as "living filters" to process sewage effluent. Where soil is moderately permeable and the effluent evenly distributed, forests bind or take up excess nutrients as well as other polluting chemicals and filter out particulates.

Forest preserve in Cook County, Illinois.

The Morton Arboretum near Lisle, Illinois.

Sewage sludge, a product of wastewater processing, can be used as a fertilizer and soil amendment for trees. However, because sewage sludge may contain high concentrations of toxic heavy metals, it often cannot be used on crops, vegetable gardens, or pastures that provide part of our food supply.

Arboretum research. A privately endowed foundation here in Illinois, the Morton Arboretum at Lisle, identifies trees suitable for cultivation in the Chicago area and upper Midwest. The arboretum maintains some native forest, a collection of living trees from throughout the world, and an herbarium. Genetic material in this collection may provide trees that can tolerate air pollution, street salts, landfill gases, and the harsh conditions of mine spoils.

Experiment Station forest scientists and Morton Arboretum staff are planning a cooperative study of allelochemicals. Produced by some trees, allelochemicals are substances that have a toxic or stimulatory effect on other plants.

Work in progress. Teaching and research programs at the University of Illinois are helping to improve our use of urban forests for the benefit of Illinois citizens. The urban forestry class, for example, has designed a noise and dust barrier of trees for a foundry in Decatur. Researchers have studied the effects of heavy metal pollutants on tree growth and feedlot runoff on a forested watershed. The findings will be useful in establishing tolerance levels and systems for dealing with these pollutants.

In other research, we have studied the selection, biology, and cultivation of bottomland tree species, including eastern cottonwood, sycamore, and alder. This work has provided a basis for improving production on wetlands such as urban floodplains and wastewater discharge areas. These and other research projects can help urban society use trees more effectively to improve the quality of human life.

Jeffrey O. Dawson, associate professor of forestry

Two-Legged Species Invades Forests

Robert A. Young

Forest scientists have recently begun examining a species that is being found more and more commonly in the forests of Illinois. For many years foresters have studied the detailed characteristics of forest trees and their interrelationships with other forest plants and animals. Only during the last few years, however, have researchers in forestry started looking closely at *Homo sapiens*, who invades our forests, looking for inspiration and recreation.

The use of lands for these purposes has become increasingly important, especially in Illinois and other populous areas of the country. Forests and other wildlands can provide escape from crowded social settings and as a result are being used by more visitors than ever before.

Contemporary forest managers must know about the psychological needs, preferences, and characteristics of this human species, just as traditional foresters had to know about the nutritional needs, site preferences, and growth characteristics of each tree species growing in the forest. Even as the management of forest land becomes more complex, foresters must now, in addition, consider the social aspects of forestry.

One of the most heavily used forested areas in Illinois is the Forest Preserve District of Cook County. About 7 million people a year visit the 65,000 acres of forests and meadows in these preserves. Scientists in the Department of Forestry at the University of Illinois recently studied a sample of the users to learn more about them and the reasons for their visits.

We discovered that most of the users are relatively young, well educated, and affluent. They generally live near the sites they use, drive there from their homes, and travel less than 15 minutes to reach the area. A major benefit from visiting these forest preserves, the users report, is a sense of peace and quiet. They strongly dislike anything that detracts from that feeling.

Unfortunately, distractions are often caused by other visitors. By understanding the source of dissatisfaction, forest managers can implement plans to reduce intergroup conflicts that can result in the loss of this sense of peace and quiet.

The forest itself can also be managed with the users' preferences in mind. For example, users find open fields with scattered groves of trees more attractive than continuous forest or completely open areas. Users also consider it more important that these places be clean and well maintained than that additional facilities be created.

Studies of this kind can aid foresters in understanding humans, those remarkable creatures who have made themselves at home in our forests. Decisions based on the information gathered will help make visits to forests an enjoyable experience.

Robert A. Young, assistant professor of forestry

Views on Illinois Forestry . . .

. From the Illinois Division of Forest Resources and Natural Heritage

It must have been a spectacular sight — Illinois before the European settlement. The vast primeval forest stretched westward until it finally met the equally formidable tall grass prairie. Battling each other for supremacy, these two great natural ecosystems arrived at an uneasy peace in which boundaries constantly changed with the vagaries of weather and other natural forces.

A mighty network of rivers and streams surrounded and laced this superb creation. Wild creatures of air, water, and land found the situation ideal. Louis Joliet, struck with awe when he first explored the area, resolved to seek permission from his king to settle in this land so blessed with natural resources.

In those times, 40 percent of Illinois was covered with forests. Today, they occupy less than 10 percent of the land, or approximately 4 million acres. More than 99 percent is in deciduous trees, with oaks and hickories in a clear majority. The potential for growing high quality trees in substantial volume is enormous.

One central fact is paramount to understanding the issues, concerns, and problems related to our forest resource: more than 90 percent of the acreage is privately owned. This resource and these owners need assistance. Recently, Illinois forests have been threatened by severe economic pressure. They must compete with more profitable annual cash crops and share the burden of taxation, which is not always in proportion to their income-producing capabilities. Because of the space they occupy, forests must also compete with new roads and reservoirs, factories and condominiums, to say nothing of the needs of four-row pickers.

Many states encourage the perpetuation of forests through a tax system that recognizes the value of the tree crop and the social benefits inherent in healthy forests. Unfortunately, Illinois is not one of these states. Wildlife habitats, watershed protection, weather amelioration, and aesthetics, as well as nuts, berries, mushrooms, and the like are all viewed as a private donation to the public. Yet the privately owned forests scattered throughout the state contribute immeasurably to wildlife diversity and numbers. Our forests simply can't be taken for granted. To do so means that they will soon be so seriously depleted that entire species will no longer be found in appreciable numbers in Illinois.

The conversion of forest land to agriculture and other uses is frightening. Riverine ecosystems that were formerly protected by forests have been destroyed. Upland forests have been converted to cropland or seriously degraded by grazing livestock. And forest ecosystems have been damaged and disrupted by developers for homesites and industry. If this trend is to be reversed, we must explore incentives and new programs for maintaining, preserving, and expanding the forests of Illinois.

Forests are the foundation upon which so many plants and animals depend. We dare not delay much longer in addressing the problem, which calls for bold, new programs. The alternatives are unthinkable to those who love our forests and the plants and creatures that live there.

Allan S. Mickelson, state forester and chief of the Division of Forest Resources and Natural Heritage, Department of Conservation

. . . From the Shawnee National Forest

Illinois, like most of the midwest prairie states, has long been known for its rich farmland and thriving agricultural industry. For several decades we have depended on other parts of the United States and Canada for wood products. Recently, however, the rising costs of transportation, changes in the technology related to wood production, and increased public concern over local economic needs have spurred a new interest in Illinois forests and forestry.

Even though Illinois is not known for its forests, the total acreage of woodland roughly equals the combined size of Connecticut and Rhode Island. Soils found in many of the forested areas are more fertile for tree growth than are soils found anywhere else in the world. Wood products already have a foothold in the state. For example, veneer from well adapted native walnut, white oak, and red oak is in demand on local and foreign markets. The resource capability of Illinois is evident, and the time is right for midwest forestry to take a giant step forward.

New technologies are helping to improve the management of forest lands and to convert species that are low in quality and value to beneficial uses. Opportunities are opening up for new industries and products. Intensified management and care of forested areas is now possible without depleting the raw materials or compromising the recreational and wildlife values of forests.

Through genetic research, trees are being developed to meet the needs of urban environments and to anticipate the demand for fast-growing species that are high in value or that have high energy and chemical yields. Superior trees for some of

... From Southern Illinois University

these uses are now being planted. Imagination is the main constraint on developing the potential of forestry in Illinois.

We have every indication that a renewed interest in the many facets of applied forestry can have positive effects. The state's economy will benefit, the quality of life for urban residents will be enhanced with the abatement of noise and air pollution, and our forests and wildlife populations in rural areas will be improved.

The major institutions of the state are working cooperatively to fulfill their leadership and service roles. The University of Illinois and Southern Illinois University are working together to redefine goals, assess scientific skills, determine the best use of their capabilities, solve problems, and assist resource managers. Staff members from the Department of Conservation and the Shawnee National Forest are involved in major planning efforts to give renewed direction to management of forest lands.

In addition, the North Central Forest Research Station will conduct the first statewide survey in seventeen years. Legislators and other elected officials have also become actively interested in improving the use of our 4 million acres of forest land.

For several decades the forests of Illinois have been a fairly dormant resource, no doubt for good reasons. But the future promises to be a time of great sensitivity to the benefits provided by forests. The economics of improved management will truly make forests attractive as an alternative use of land.

Kennith D. Henderson, supervisor of the Shawnee National Forest

Overlooked as a renewable natural resource, Illinois forests are an unrealized opportunity. Put in other terms, Illinoisans are losing out on many benefits from the state's forested lands. These benefits include forest recreation, protection of wildlife species, an abundance of wood products and fuel wood, and cost-effective erosion control on much of the state's 900,000 acres of marginal land. Forests can also help protect and improve the quality of water flowing in our streams. Associated with these benefits are many employment and manufacturing opportunities.

Extensive forests still grow in southern and western Illinois and along our major streams and rivers. More than 35 Illinois counties have at least 10,000 acres of forested land. Dozens of native trees and shrubs occur in nearly endless combinations to form numerous forest types. These types vary from bald-cypress swamps in the bottomlands of southern Illinois to upland hardwood forests throughout the state. Whether through privately owned woodlands or the system of public parks and forests, virtually every Illinois resident can have access to forest recreation.

Illinois forests are minor only on a relative scale. In absolute terms they represent a major resource with potentially significant benefits to the state, region, and nation. Why, then, has the potential of these lands remained undeveloped?

The reasons are varied and complex. According to recent information released by the Illinois Division of Forest Resources and Natural Heritage, forested lands are divided into small, isolated tracts interspersed with agricultural land. Woodland owners have few incentives for practicing forestry because they don't know what their woodlots can be used for and don't have specific objectives in view. Furthermore, markets are inadequate, management techniques are unsatisfactory, and attention is usually focused on agricultural production. Ironically, demand for Illinois forest products and services may remain low because residents rely on other states that are better known for their forests.

Likewise, government policies and assistance programs affect the incentive to manage forests. Low utilization can also be blamed on the real estate tax structure for forest and agricultural land, unemployment compensation laws, highway systems and road regulations, and even on the motives for owning land.

What does the future hold for Illinois forests? During the past two years forestry leaders have discussed this question at major conferences held in the state. They believe that Illinois can realize many of the benefits offered by its forests, especially as forest production in the southeast and Pacific northwest falls short of demand. But first we will have to learn more about the status of our forests, increase people's awareness of potential uses, and develop incentives for forest management.

Many individuals and agencies seem willing to take up the challenge, and programs are now being planned. We have good reason to be optimistic. By working together, forest landowners, users, and professional foresters can begin to realize the benefits offered by Illinois forests.

George T. Weaver, chairman, Department of Forestry, Southern Illinois University

In Progress

Legumes on set-aside land

Set-aside acreage, even though not producing corn or soybeans, can provide a welcome financial savings. The key is to plant legumes such as alfalfa and clover, which supply inexpensive nitrogen in abundance for a corn crop planted later on. Control of soil erosion is another bonus.

Don Graffis, Extension agronomist, believes it's best to look at the set-aside program optimistically. "A stand of clover or alfalfa," Graffis says, "can contribute a surprisingly high amount of nitrogen per acre at a relatively low cost."

Farmers who plant legumes for future hay crops should choose high yielding, high quality varieties that are resistant to pests. If legumes are planted just for cover, high nitrogen-fixing species should be considered. Oats seeded at one bushel per acre with the legumes provide a fast-growing ground cover that helps control erosion and weeds.

During establishment of a high yielding hay crop, spring oats sown with perennial legumes may need to be clipped at about 40 to 50 days of growth to reduce vegetative competition. If the seedings are to serve as a cover crop only, the oats do not need clipping until the late boot to early heading stage. At this stage oat vegetation may be excessive and smother out some of the interseeded legumes. Usually enough legume plants survive to compete with weeds, protect the soil from erosion, and fix substantial amounts of nitrogen. Weeds found among legumes that have not been seeded with a companion crop can be controlled by mowing two to six times or by using herbicides.

Under the right conditions, Graffis says, relatively high rates of nitrogen can be fixed by certain legumes; for example, alfalfa can fix 195 pounds per acre; ladino clover, 190; sweet clover, 120; alsike clover, 120; and red clover, 120. When seed cost and nitrogen production are compared, ladino and alsike clover have the lowest seed cost per pound of nitrogen fixed. Among the perennial legumes, the difference in seed cost per pound of nitrogen fixed is relatively small when all seeding costs are included. These perennial legumes can fix substantial amounts of nitrogen at a low cost.

Legume roots fix nitrogen through a symbiotic relationship with Rhizobium bacteria, but different legumes require different strains of Rhizobium. Inoculation of legume seeds with the correct strain helps to ensure high rates of nitrogen fixation.

About half of the nitrogen produced by legumes will be available for crop growth the first year after crop destruction and about one-fourth the second year. A good stand of alfalfa may contribute roughly 100 pounds of nitrogen per acre to a corn crop the first year after alfalfa and 50 pounds the following season.

Alternative roughage for horses

The estimated 300,000 horses in Illinois consume about one million tons of roughage dry matter every year. During the winter months in particular, most of this roughage is in the form of hay. But keeping horses supplied with hay can be expensive and difficult when the weather is uncooperative at hay-making time.

Researchers at the University of Illinois have been investigating alfalfa haylage as an alternative source of roughage for horses, says Laurie Lawrence, assistant professor of animal science. Hay is forage that is dried and baled in the field. Haylage, on the other hand, is forage that has been slightly wilted and then ensiled in an airtight silo.

Unlike hay making, ensiling of forages is less dependent on weather conditions. Ensiling can also improve low quality roughages. Alfalfa haylage may therefore offer a suitable alternative for feeding horses when hay is unavailable or prohibitively expensive.

For several years alfalfa haylage has been fed as the roughage source to pregnant mares and growing horses in the University horse herd with very successful results. Birth weights of foals from these mares have been similar to those from mares fed alfalfa hay. Growth rates of yearling horses fed haylage have also been satisfactory.

Researchers will continue to investigate the feasibility of feeding alfalfa haylage to growing and working horses.

No volunteers wanted

Volunteer corn in soybean fields is on the rise in Illinois. The size of this unwanted crop depends on the amount of corn lost from the previous corn crop.

"If this loss is low, then the volunteer corn problem can be minimized," says Lyle Paul, DeKalb County Extension adviser. "But with more corn-soybean rotation and less tillage, the problem of volunteer corn has increased." Tillage can play a large part in the control of volunteers. Fall moldboard plowing before the 1980 crop year knocked out 90 percent of the volunteer population, and fall chisel operations 80 percent. But more farmers are moving toward less tillage, and they will have to rely on other methods of control, usually herbicides, Paul says.

Recommended herbicides can be effective enough to pay for the cost of treatment many times over. Volunteer corn populations were reduced by 75 to 100 percent and the corn grain yield by 80 to 100 percent in studies at the Northern Illinois Agronomy Research Center. Treflan, a dinitroaniline herbicide, was less effective, reducing corn populations and yield by only 50 to 90 percent. Soybeans in treated plots yielded 6 to 12 bushels more per acre than did soybeans in untreated plots. Getting rid of volunteer corn also keeps the soybean crop free of foreign material (corn in this case) and excess moisture; otherwise, growers can be docked at the elevator.

Funk Awards

Three College of Agriculture staff members were cited for "outstanding service to agriculture" in the thirteenth annual Paul A. Funk Recognition Program, held in Urbana on February 28. Each citation was accompanied by a cash award. Funds for this program are provided by the Paul A. Funk Foundation of Bloomington.

Jimmy Howard Clark is internationally known for his research in ruminant nutrition.

Dr. Clark's extensive studies of the feeding value of urea have played a major role in determining the nutrient requirements of high-producing cows and the extent to which nonprotein nitrogen can meet these requirements.

Dr. Clark and his associates were the first investigators to demonstrate that the excessive uptake of arginine, ornithine, valine, leucine, and isoleucine by the lactating mammary gland provide carbon and nitrogen for the synthesis of nonessential amino acids. They further demonstrated that infusion of glucose and essential amino acids at the level of the abomasum will increase milk production in dairy cows. In addition to his work in nitrogen metabolism, Dr. Clark has conducted a comprehensive series of experiments dealing with the preservation of high-moisture corn and the nutritional value of high-oil and high-lysine corn for lactating cows.

Dr. Clark is the American Dairy Science Association representative to the American Feed Manufacturers Association Nutrition Council and secretary of the American Dairy Science Association Production Council. In recognition of his achievements in dairy science research, Dr. Clark was given the American Feed Manufacturers Award in 1980. The following year, he was appointed to the Committee on Animal Nutrition of the National Research Council.

Edward George Perkins is recognized both here and abroad for his outstanding contribution in lipid chemistry.

An innovator in developing new chromatographic methodology, Dr. Perkins pioneered the techniques used for separating the complex mixtures of triglycerides found in natural fats and oils. These techniques have been adopted by industry to monitor changes in lipid composition during thermal processing and by other scientists in the study of lipid metabolism. Dr. Perkins' investigations of the thermal oxidation of fats and oils have added greatly to our knowledge of the chemical changes that take place when these products are used in deep-fat frying.

More recently, Dr. Perkins has conducted extensive research to discover the nutritional and toxicological consequences of the Maillard reaction — the nonenzymatic browning that occurs when foods are processed. He has also devised a simpler and more accurate method for determining the *trans*-fatty acid content of fats, and contributed significantly to an understanding of the distribution of chlorinated pesticides during the processing of soybean oil.

Dr. Perkins is a Fellow in the American Institute of Chemists, a member of the board of directors of the League for International Food Education, and former president of the American Oil Chemists' Society. Among the many honors he has received are the Merit Award in Chromatography, Arnold O. Beckman Research Award, and a Certificate of Recognition from the Illinois House of Representatives.

Samuel Franklin Ridlen has achieved national recognition for his contributions to the poultry industry.

Professor Ridlen's writing and speaking skills, ability to develop creative and informative programs, and deep interest in helping people solve their problems have made him one of the most effective poultry extension specialists in the United States. His *Monthly Poultry Suggestions*, a newsletter originally written for the Illinois poultry industry, is currently distributed in 39 states and 29 foreign countries. In the words of a colleague, "Sam Ridlen has that rare quality of being able to give scientific data a relevant meaning for the practical producer."

Professor Ridlen has also worked extensively with 4-H and other youth groups, and his judging teams have won the National 4-H Poultry and Egg Judging Contest more often than those of any other state. In 1974 he initiated a 4-H Incubation and Embryology Project that was subsequently adopted by the Chicago public school system. More than 580 teachers and 33,000 young people have participated in this project.

Professor Ridlen has received the Charles Pfizer Extension Teaching Award, G.R. Carlisle Award for Outstanding Extension Teaching in the Department of Animal Science, and the Illinois Poultry Industry Council Golden Feather Award. In 1982 he was given the coveted USDA Superior Service Award for "his visionary leadership and exemplary service in developing a flexible, highly effective extension program for adults and youth in the State of Illinois and the nation."

Publications

More About Forestry in Illinois

Publications listed here provide additional information about forests and forestry. Requests for copies should be sent directly to the addresses provided.

Chain Saw Safety Tips; by C.S. Walters. Illinois Cooperative Extension Circular 1170. 1979. 11p. Single copies free.

Office of Agricultural Publications
University of Illinois
123 Mumford Hall
1301 West Gregory Drive
Urbana, Illinois 61801

Forest Planting Practices for Illinois. 40p. $2.

Illinois Technical Forestry Association
P.O. Box 477
Pittsfield, Illinois 62363

Forest Trees of Illinois; by Robert Mohlenbrock. Department of Conservation. 1972. 328p. $2.

Division of Forest Resources and Natural Heritage
Northwest Office Plaza
600 North Grand West
Springfield, Illinois 62706

Important Forest Trees of the United States; by Elbert Little, Jr. Agriculture Handbook No. 519. USDA-Forest Service. 1978. 70p. $5. Stock #001-000-03722-6.

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

Manager's Handbook for Black Walnut; by Richard Schlesinger and Dave Funk. GTR-NC 38 North Central Forest Experiment Station. 1977. 22p. Free of charge.

USDA-Forest Service
1992 Folwell Avenue
St. Paul, Minnesota 55108

Manager's Handbook for Oak and Associated Species. GTR-NC 37 North Central Forest Experiment Station. 1977. 25p. Free of charge.

USDA-Forest Service
1992 Folwell Avenue
St. Paul, Minnesota 55108

Recommended Sulviculture and Management Practices for Illinois Hardwood Forest Types. 1972. 45p. $2.

Illinois Technical Forestry Association
P.O. Box 477
Pittsfield, Illinois 62363

Woodlands and Wildlife; by Jerry Hassinger et al. 1979. 67p. $2.

Pennsylvania State University
College of Agriculture
University Park, Pennsylvania 16802

Woodlands for Profit and Pleasure; by Reginald D. Forbes. 1971. 244p. $5.

American Forestry Association
1319 18th Street, N.W.
Washington, D.C. 20036

Single copies of the following publications are available free of change from:

Department of Forestry
University of Illinois
110 Mumford Hall
1301 West Gregory Drive
Urbana, Illinois 61801

Chart for Identifying Some Common Native Forest Trees of Illinois in Summer. 4p.

Christmas Tree Series. Leaflets 14 through 17.

Firewood Economics. Leaflet 10. 4p.

Growing Christmas Trees in Illinois; by A.R. Gilmore. Illinois Cooperative Extension Circular 1171. 1980. 35p.

Growing Walnut for Profit and Pleasure. Fine Hardwoods/American Walnut Association. 1980. 12p.

Improve Your Woodlot by Cutting Firewood. USDA-Forest Service. 9p.

Planting Black Walnut for Timber. USDA-Forest Service Leaflet No. 487. 1976. 10p.

Tree and Shrub Planting in Illinois. Illinois Department of Conservation. 10p.

University of Illinois at Urbana-Champaign
Agricultural Experiment Station • R.G. Cragle, Director
Urbana, Ill. 61801 • Publication • 9M

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Illinois Research

Spring 1983

Reflections on the past and future of agricultural crops

Illinois Research

Agricultural Experiment Station
Spring 1983

College of Agriculture, University of Illinois at Urbana-Champaign, Volume 25, Number 2

The Cover

Interlocking research activities at the Agricultural Experiment Station have contributed significantly to the outstanding harvests achieved on Illinois farms in recent years. Further improvements in genetics, the plant environment, and pest control will enable us to meet domestic and foreign food needs in years to come. The photomontage suggests the parallel lines of research that are required in crop improvement.

"At a time unlike any in the past, we must envision the future."

Illinois Research

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Plant Science and Society

If we were to turn the calendar back to 1888, the year the Illinois Agricultural Experiment Station was established, we would find George E. Morrow, agriculturist, at work in his plots. By season's end he and his assistant had tested dozens of corn varieties. Ever since those early experiments, Station scientists have been using their talents to grow better crops.

While one group of scientists improved plants through intensive selection and cross breeding, others concentrated on improving nutrient availability and pest control. These hand-in-hand research efforts have led to steady advances in the yields of field and vegetable crops in this country. For many years Illinois has been a leader in this effort. Continuing progress is vitally necessary to ensure adequate food supplies for a growing population in the United States and throughout the world.

The task of improving yields has been slow and painstaking. During the past twenty years, for example, corn yields have risen only about one percent each year as a result of improvement in genetics and the plant environment. Looking to the future, we see some real possibilities for accelerating this rate of yield increase.

New techniques are now available for making combinations of genetic material within the plant genome. Compared with conventional techniques, the new ones will greatly reduce the time required for breeding. Clearly a new era in plant improvement stretches before us.

But "new" environments will be needed to support these "new" plants if their genetic potential is to be realized. The availability of nutrients must be restudied to allow for the complexities found in the nutrient exchange capacities of soils. Supplemental water through irrigation will take on added importance. Protecting plants against weeds, insects, and diseases also calls for new strategies. At one time, chemical control appeared to be the best way to protect crops. We now know that interlocking strategies must be evolved, using rotations, breeding for resistance, selecting insect predators, and generally improving crop management.

As our knowledge of plant genetics unfolds, we will continue to develop the environments so necessary for the performance of improved crops. Our efforts will be carried out in the proud and rigorous tradition begun by George Morrow. The enormous potential for advances in crop yields holds forth the promise of meeting worldwide needs for food in the 21st century.

Benjamin A. Jones, Jr., associate director of the Agricultural Experiment Station

Agricultural Crops

From Wilderness to Farm: The Odyssey of Plant Domestication

Jack R. Harlan

All major food crops grown today were domesticated from wild progenitors in prehistoric times. Some agricultural systems have evolved with only food crops, while others depend heavily on livestock and poultry. In Illinois, agriculture is a mixed system, with a very large share of primary crops such as corn and soybeans going into animal rations. Forage and range plants also contribute enormously to the livestock industry.

Plants protect and improve our soils, lend stability to managed ecosystems, support wildlife, and enhance the quality of human life. Future advances in agriculture will depend first of all on improving the plant resource base. To do so systematically, we need to understand where we have been and where we are going. A study of the past is one of the most reliable keys to the future.

The processes involved in plant domestication are complex and are not well understood because they have not been studied in much detail. Yet the changes that have taken place in crop plants during the course of their evolution can provide valuable clues on how to accelerate desirable trends and arrest or alter undesirable ones. Over the centuries, human manipulation has brought about some changes that are clearly beneficial to crop production and some that can be a hindrance.

Losses due to domestication. Somewhere along the road to domestication, photosynthetic efficiency in wheat declined. At high light intensities, photosynthesis in wild wheat is about twice as efficient as in cultivated wheat, as plant physiologist L.T. Evans (CSIRO, Australia) and his co-workers found. Efficiency is measured by weighing the carbon dioxide fixed per amount of leaf area.

Compared with its cultivated relative, wild wheat may not be any more productive, because the leaves tend to be smaller. Nevertheless the trait for efficiency is there, and it's an important one. Quite possibly we can recover some of this efficiency once we learn more about what limits photosynthetic rates. We do know that leaves of wild wheat become light saturated at higher levels than leaves of domesticated wheat. As a result, the wild plants can use radiant energy more efficiently.

Another loss is found in the protein content of seed crops. Grains of domesticated cereals, although larger than most of their wild counterparts, are considerably lower in protein. Wild einkorn wheat, for example, may contain more than 22 percent protein, while among cultivated varieties, a good, hard red wheat may contain 14 or 15 percent and soft wheats an even lower percentage. In this case, the difference may be due to seed size. During the process of domestication, selection for larger seed results in a greater increase in endosperm size relative to the embryo. Compared with the embryo, the endosperm has more starch and less protein.

But wild cereals occasionally have larger grains than do domesticated cereals. Some races of wild wheat, barley, and oats found in Palestine bear seeds that are larger than those of most cultivated varieties. Wild races provide good genetic sources for high protein content. Plant breeding procedures can be used to recover at least some of the protein lost during domestication. The oil content of domesticated oats has also been increased by using wild oats in a breeding program.

Still another loss during domestication is the stability of resistance to diseases. For decades plant breeders have been playing a catch-up game with new, virulent races that evolve as fast as appropriate genes for resistance can be inserted. The game has been particularly intense in small grains, vast acreages of which are periodically devastated by outbreaks of rust, scald, virus, and the like. The basic problem is nearly universal, and breeders have been looking for strategies other than breeding for simple genetic resistance.

Natural defenses. Recently some breeders and plant pathologists have been studying resistance as it has evolved in wild populations of barley, wheat, and oats in the Near East. There, one can study large, natural populations and analyze their genetic defenses against the same diseases — and often the same races

of a disease — that cause serious problems in the United States.

These studies have shown that natural defenses are much more complex than the defenses we have bred into our varieties. Too often we depend on simple genetic resistance, which may give immunity to specific races of a pathogen but not to others.

Never free of diseases, wild plant populations do not seem to generate epidemics. The ever-present diseases do little damage because they are kept under control by a complex array of genotypes. Although no single genotype — of wheat, for example — is resistant to all the races of a disease, each genotype is rare enough that a particular race cannot build up to epidemic proportions (Fig. 1).

A breeding strategy similar to the complexity found in wild populations should help us recover the stability of disease resistance that was lost during domestication. This concept, which applies to insect resistance as well, has become fundamental to most integrated pest management programs.

Chemical nulls. Plants produce a great many chemical compounds during normal growth and development. The function of some of these compounds is obvious. Sugar, starch, oils, and sometimes protein provide energy. Oils are involved in membrane function as well, and proteins are necessary for metabolic processes, membrane function, genetic control, and other vital functions. In addition, we now know a good deal about the function of DNA, RNA, cytochromes, and associated enzymes.

The function of certain other compounds, called secondary metabolites, is unknown or speculative. It has been suggested that many of them protect the plant from diseases, insects, stress, and other hazards. In fact, some compounds are poisons and still others are anti-metabolites that interfere with the use of a plant for food.

Although rare, some genotypes known as chemical nulls are unable to produce one or another of these compounds. This information was brought to light by a persistent search among the several thousand accessions in the world soybean collection. So far, searches have been made for nulls of five different chemicals, and two or more nulls have been found in each case. The null genotypes appear to grow and perform just as well as their normal counterparts. In nursery trials, the compounds do not seem to be necessary or even useful. In one case, nulls were much more common in wild soybeans than in cultivated ones.

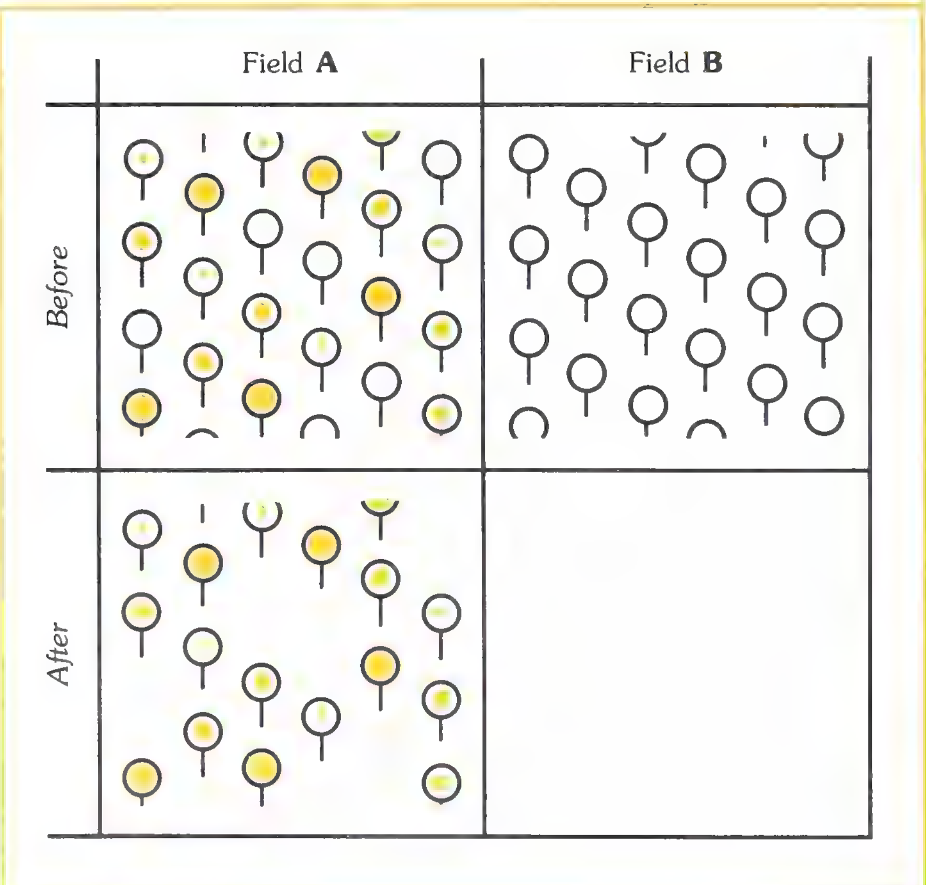

Fig. 1. Two wheat fields. In field **A**, planting many genotypes simulates natural disease defenses of wild populations. For example, a race of rust attacking only one genotype finds enough host plants to survive but not to become epidemic. In field **B**, typical of U.S. wheat fields, all plants are of the same genotype. If a race virulent to this genotype develops, an epidemic can result, causing great damage.

Photosynthesis in Tomorrow's Agriculture

Doyle B. Peters

Life as we know it could not exist without photosynthesis. During this process, green plants and certain bacteria convert solar energy, water, and carbon dioxide into chemical energy. Yet from these modest ingredients, plants are able to produce the food, fuel, fiber, and oxygen that are essential to human life.

A pioneer institution in photosynthetic research, the University of Illinois brought scientists Robert Emerson and Eugene Rabinowitch to the campus in 1946 to conduct research in this area. Since then, we have become one of the strongest and most broadly based centers of photosynthetic research in the world. Studies range from the submolecular level to whole-plant systems. The College of Agriculture, in cooperation with the Agricultural Research Service of

The evolutionary implications of this finding are not clear, but the practical considerations are: we can breed soybeans that do not produce specified, undesirable chemicals. One chemical, for example, inhibits the digestion of soybean protein. A null that has been found for this chemical should reduce the cost of processing soybeans. The null for another chemical that causes oil to turn rancid should make soybean oil more stable and reduce the need for extensive processing to increase shelf life. Yet another compound breaks down urea so that is cannot be mixed with soybeans in animal rations. Obviously a null for this enzyme would be very useful.

Jumping genes. Detailed analyses are now under way to determine the relative roles that different classes of DNA play in crop evolution. At the Plant Breeding Institute in England, for instance, R.B. Flavell and his team have shown that diploid rye has about twice as much DNA as diploid wheat with the same chromosome number. The extra DNA in diploid rye is of the regulatory kind. In other words, although wheat and rye have almost the same genes, the genes are regulated differently. This finding is very much in line with the more advanced DNA research among animals.

Natural mutation rates are too slow for the rapid changes we want in crop improvement. Changing the regulatory fraction of DNA now seems to be the best way to accelerate the pace. Regulatory fractions include transposable elements, or "jumping genes," which can move to another place on a chromosome or from one chromosome to another.

We are just beginning to learn about the regulatory classes of DNA. At present our control over the movement of transposable elements is inadequate and we lack dependable methods of transferring extracted DNA from one plant to another. But techniques for DNA manipulation are advancing so rapidly that these constraints may soon be removed. Clearly we need a better understanding of domestication processes at the molecular and biochemical level.

The paramount role of plants in our agricultural ecosystems is easily recognized, but exactly how plants became domesticated over the millennia is still not clear. Continued crop improvement depends on our learning more about the processes of domestication.

Jack R. Harlan, professor of plant genetics

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the U.S. Department of Agriculture, has achieved prominence in this work, especially in biochemical and whole-plant studies.

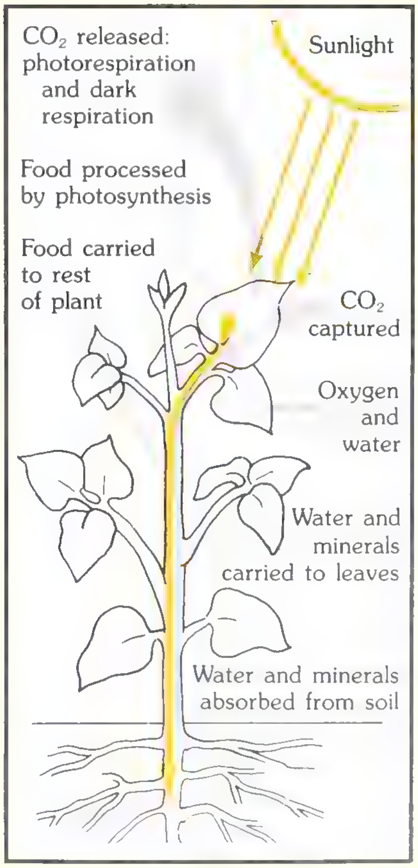
The response of plants to the environment, and to water and temperature stress in particular, is of special interest to agriculture. We need to learn more about stress because it can interfere with photosynthesis and hence with yields. In fact, stress causes greater yield losses than does any other condition that influences productivity. Basic information obtained from our research is used to construct models for predicting yields, growth, and growth-related factors of economic significance.

Cultivars within a single species vary genetically in how efficiently they convert solar energy to chemical energy. The variation is significant enough economically to warrant breeding studies of this trait in agricultural crops.

Genetic variation from one species to another is also quite large. The greatest diversity is found between C_4 (four-carbon) plants such as corn and C_3 (three-carbon) plants such as soybeans. In C_3 plants, a phenomenon called photorespiration in effect robs a plant of valuable carbon compounds fixed during photosynthetic assimilation. During photorespiration these compounds are rapidly oxidized to carbon dioxide, which escapes into the atmosphere. The problem is of considerable interest to researchers, because a reduction in carbon losses due to photorespiration could add up to large dividends for producers.

With improvements in photosynthesis, crop production might conceivably increase twentyfold. An increase of this magnitude would enable farmers to supply most of the food, fiber, and energy needed worldwide. To do so, however, we must gain a better understanding of the photosynthetic process and the conditions that influence it. With this end in view, agricultural scientists have increased their efforts in the study of photosynthesis.

Doyle B. Peters, professor of soil physics and research leader, Agricultural Research Service of the U.S. Department of Agriculture



Processes involved in the capture and release of energy. In plants such as soybeans, valuable carbon compounds are lost through photorespiration.

A New Era in Crop Production

Donald A. Holt

I remember how my grandfather used to slap the reins over the horses' rumps as they heaved that high-wheeled, steel-tired wagon up the approach and into the crib driveway. When the wheels rolled onto the dump beams, he pulled the team to a stop. Then using a hand crack on the wall, he tipped the beams and wagon to a steep angle. As he loosened the endgate, the ears of corn began to flow, dragged sideways by chain and slat, lifted upward in the elevator cups, then sliding and dropping back down into the sides of the crib, there to dry and wait for the sheller.

Grandpa sat behind the wagon, controlling that golden flow with his feet. Occasionally he tossed an extra-long, well filled ear into a basket beside him. These special ears, plus some he had picked while walking the fields before harvest, were eventually stuck on nails in the ceiling joists above us. In spring the ears would be shelled two at a time in an old hand-cranked sheller. This was the seed corn, the beginning of next year's crop.

Hybrids. Open-pollinated corn, like that selected by my grandfather, was grown on all U.S. corn acreage until the early 1930s. After that, it was rapidly replaced by hybrid corn, produced by crossing inbred lines. Compared with open-pollinated varieties, the first hybrid corn germinated better (see box), grew faster, and yielded a little more. Hybrids had what they call heterosis, or hybrid vigor.

The most important feature of hybrids was that corn breeders had much greater control over the process of developing corn varieties.

Making Sure That Seeds Germinate

James B. Sinclair

To be assured of a satisfactory stand, a farmer must plant viable seeds that will produce vigorous seedlings. Several tests can be used to determine viability, but germination tests conducted under controlled conditions are used most often by seed testing laboratories. The results obtained are a measure of seed quality and, along with cultivar purity and freedom from other seeds, are used in the seed certification process.

The number of viable seeds in a lot before planting or testing is called the germination potential. Often the potential is not realized, however, because microorganisms are present in the seeds or in the soil.

Mechanical damage makes seeds vulnerable to microorganisms and adverse environmental conditions. Damage can occur at the time of harvest, when seeds are stored, during bagging, or at planting time. Despite damage, some seeds may still germinate in the laboratory or field, given favorable conditions, but the seedlings soon die because the embryos have been injured or attacked by microorganisms.

Fungi, bacteria, and other microorganisms are found on both the inside and the outside of the seed coat, in the embryo, and in the soil. For example, most of the fungi and some of the bacteria attacking soybean seeds first colonize the seed-coat tissue when seeds are about to mature in the field, as our plant pathologists have shown. During storage these microorganisms sometimes travel from one seed to another. Then, when the seeds begin to germinate and absorb moisture, the fungi and bacteria migrate from the seed coat and attack the embryo or seedling.

Damage caused by insects in the field or in storage may be just as harmful to germination as is mechanical damage. But in addition to the damage itself, insects can also introduce pathogens directly into seed tissues or leave openings through which fungi and bacteria on the seed surface enter the tissues. If the embryo has not been injured by the feeding, the seed will remain viable until germination begins. At that time, the microorganisms in or near the wounds attack and kill the embryo.

If unchecked, microorganisms thrive on some crops with a high sugar content. For example, as sweet corn becomes sweeter through breeding, the seeds become more susceptible to soilborne microorganisms (see Dickinson's article on page 12 in this issue of *Illinois Research*). Sweet corn seeds with a high sugar content will have a low rate of emergence in the field even though they are free of mechanical damage and soilborne microorganisms and have a germination potential nearing 100 percent. A relatively simple way around the problem is to breed corn for moderate levels of sugar and hence for resistance to soilborne microorganisms.

Resistance, particularly to seedborne fungi, is being developed in soybeans at the U.S. Department of Agriculture Regional Soybean Laboratory here on the University of Illinois campus and at other research centers as well. Fungicides sprayed on soybeans and wheat before harvest help control seedborne and soilborne fungi and also enhance seed quality. Breeding for resistance and treating with fungicides are two effective ways of realizing the germination potential of any seed lot.

James B. Sinclair, professor of plant pathology

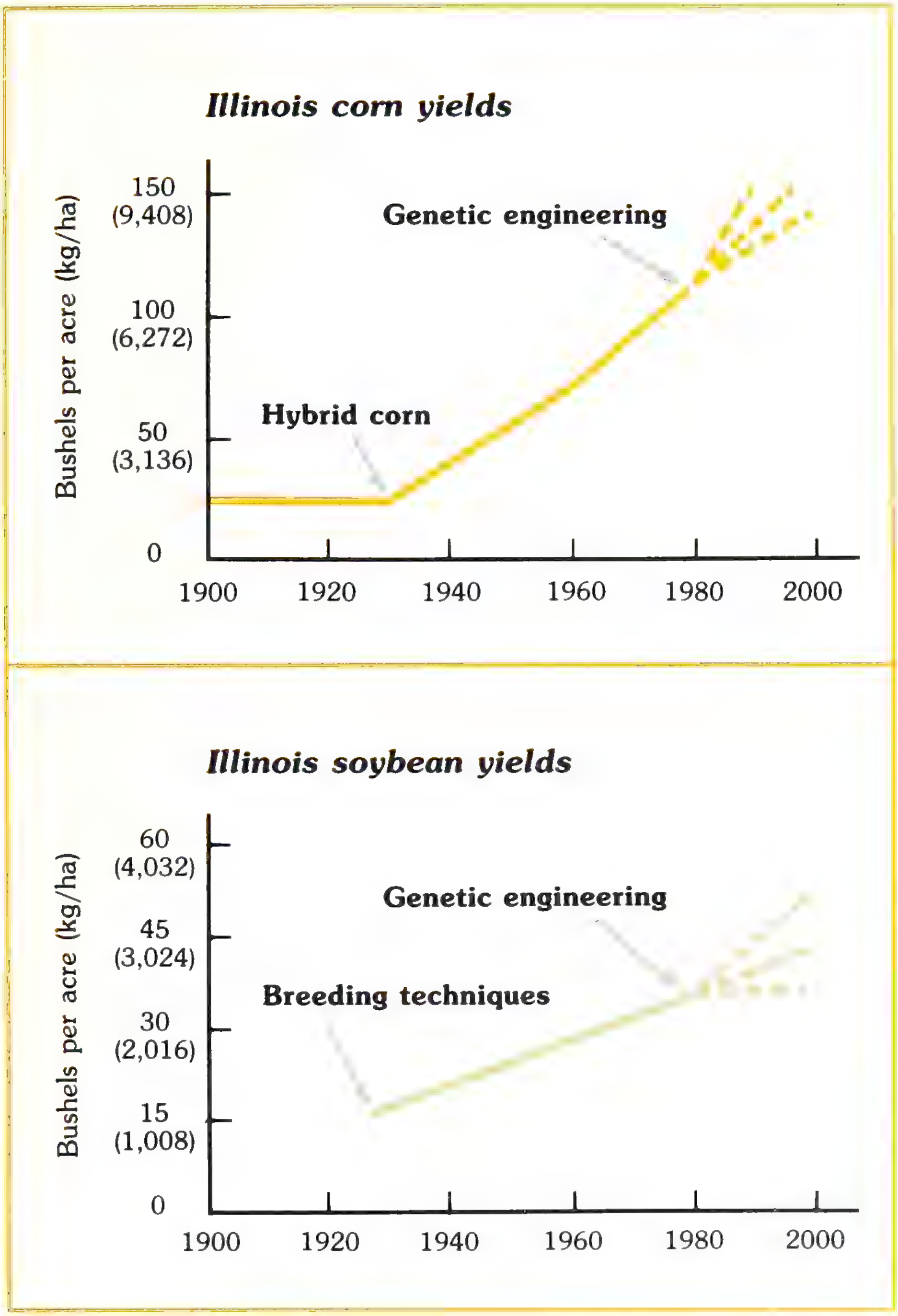


Fig. 1. Actual and projected increases in corn and soybean yields resulting from new or improved technologies. Dotted lines indicate possible future trends.

Breeders could cross lines, each of which had one or more desirable characteristics such as seedling vigor, resistance to a specific disease, or shorter, stronger stalks; the resulting hybrids might have all of these characteristics. Hybridization has been a powerful technique for improving other crops, too.

A look at the trend in corn yields reveals a dramatic change (Fig. 1). Average U.S. yields did not increase from 1900 until the late 1930s, when hybrid corn was introduced on a large scale. Between 1935 and 1983, average yields rose about 2 bushels per acre per year (125 kilograms per hectare). It's tempting to attribute this increase solely to hybrids, but populations, fertilizers, and other interlocking developments also enter the picture.

Populations. Back in the 1930s, operating our tractor-mounted corn planter was my father's job. When starting to plant, he first had to string a long wire down the side of the field. The wire, with a knot every 40 inches, was staked at each end. As the tractor and planter moved over the field, the wire snaked through the planter and around a system of guide-pulleys. Each time a knot went through the tripping device, a lever snapped back and three kernels dropped from each of the four planting units, making four hills.

The net result of this complex operation was rows of corn planted 40 inches apart. Within rows, the hills were also 40 inches apart and lined up both lengthwise and crosswise in the field. This pattern allowed my father to run our tractor-mounted cultivator in both directions, eliminating weeds between and within the rows.

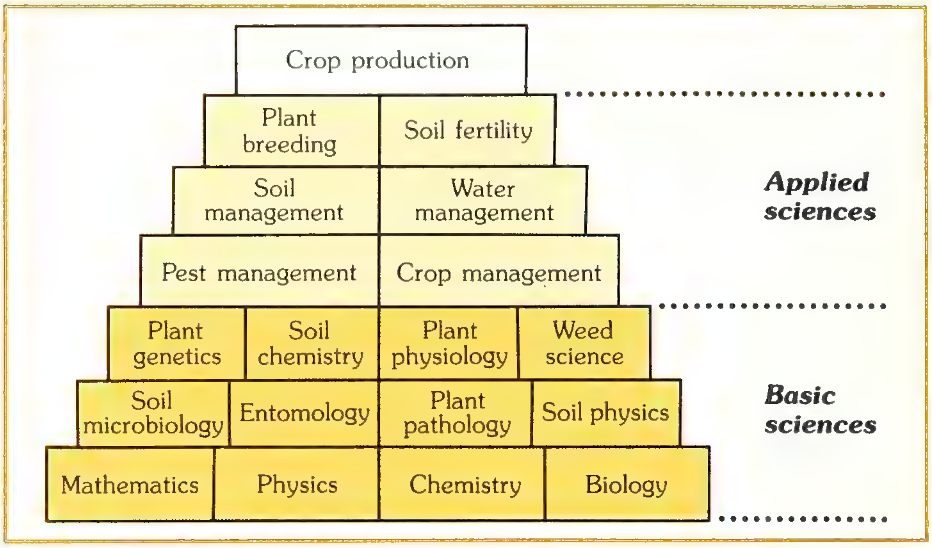


Fig. 2. The science of crop production is built on a foundation of basic and applied sciences.

The system had drawbacks, however. It took time to get off the tractor at each end of the field, restake the wire, and restring it in the planter. Once the crop was established, it had to be cultivated mechanically at least three times. The usual practice was to cultivate once lengthwise, once crosswise, and then lengthwise again. If the corn got too tall to cultivate a third time, crosswise ridges left by the cultivator were there for the cornhusker and wagon to bounce over.

Cultivation also used considerable fuel, did not kill the weeds growing close to the corn plants, and was ineffective in wet years or after the corn was 30 to 40 inches tall. Furthermore, each cultivation lopped off some roots, causing a yield reduction.

With the check-wire procedure, the population was roughly 12,000 plants per acre, or about half of what it is now. Had the open-pollinated corn that my grandfather selected been planted as thick as today, yields would have been very poor, and most of the plants would have lodged — fallen over — because of thin, weak stalks and root and stalk diseases.

Fertilizer. After 1945 the use of fertilizer, particularly nitrogen fertilizer, increased rapidly. Following World War II, that part of the wartime munitions industry that produced ammonium nitrate was directed to the peacetime manufacture of fertilizer. New varieties responded efficiently and economically to the extra nutrients. Old varieties would not have done so well because they lacked the genetic capacity to use the added nutrition.

Interlocking developments. By the mid-1950s the check wire had almost disappeared. Many conditions rendered it obsolete: chemical weed control, genetically improved corn plants, larger populations, the trend toward even spacing of plants within rows, and the need to plant large acreages quickly.

These developments vividly demonstrate the important interplay between the various areas of crop production research (Fig. 2). Advances in breeding techniques made possible more vigorous, faster growing varieties with stronger stalks and improved resistance to diseases and insects. Herbicides allowed better weed control, thicker planting, less mechanical cultivation, and higher yields. Thicker plantings of faster growing and higher yielding crops required new fertilizer and pest control strategies. New fertilizers and pesticides, in turn, had to be produced to push these varieties toward their production potential.

New problems. The changing technology of crop production solves many problems, but new ones appear, sometimes because of the technology itself. For example, when 2,4-D eliminated much of the competition from broadleaved weeds, then grassy weeds such as giant foxtail began to flourish. As a consequence, new herbicides and weed control procedures had to be developed. Even if extremely effective, however, new chemicals must be thoroughly tested to make sure they are safe and generally beneficial to society.

Resistance to one race of a disease may be incorporated into a new crop variety, but often it isn't long before another race appears. Disease, insect, and weed problems are potentially much more serious when large tracts of cropland are planted to one or two crops such as corn and soybeans. A great effort is sometimes required just to keep even with emerging crop problems.

But by and large, agricultural scientists have been able to keep well ahead of most problems. Crop yields have increased steadily over the years, and there is no indication of a slowdown. At present, because of soil, weather, and management limitations, we are probably exploiting only 30 to 50 percent of the yield potential of today's best crop varieties even in good years. To illustrate: the 1982 record corn crop for Illinois averaged 135 bushels per acre (8,467 kg/ha), or less than half the size of yields from top-yielding plots at the University of Illinois.

In addition, plant breeders are constantly pushing the genetic potential higher. Under the very best of circumstances, less than 2 percent of the solar energy now reaching a field is converted to usable biomass such as corn grain; this percentage can be improved. Obviously we have a long

way to go before fully realizing the potential.

Yield trend. What will happen to the yield trend in the future? Past gains suggest that with a breakthrough similar to hybridization we may be able to speed up the rate of yield increase. Currently, public institutions and private industry maintain a very broad system of research and development that focuses simultaneously on many aspects of crop production.

For example, as genetic potential increased, farmers were given the fertilizers, pesticides, and so forth to take advantage of the improvement. Sometimes advances work the other way around, as when scientists knew that nitrogen fertilizer could increase wheat yield. First, however, they had to breed stiffer-strawed varieties so that the high yielding plants wouldn't lodge before harvest.

Genetic engineering. Accelerating developments in what has come to be called genetic engineering promise to open a whole new era of crop production. Although somewhat oversold in the popular press, genetic engineering has enormous potential for improving crop quality and increasing production.

We often think of this field as something out of science fiction, a technique for crossing mice and men. While it certainly has some intriguing and perhaps frightening possibilities, genetic engineering is just another tool, albeit a potentially powerful one, for manipulating the genetic code. Using techniques for modifying and selecting genes, scientists can now produce drastically different strains of bacteria capable of doing things they never did before, such as making human insulin.

Applied to plants, these techniques have not been as successful, because plants are much more complex and less easily manipulated than bacteria. Progress is being made, however. A necessary step is learning how to culture single cells rather than whole plants. Individual cells can be chemically treated to modify the genetic code. They can also be selected and screened for desirable biochemical characteristics in much larger numbers than whole plants.

Once single plant cells with the characteristics desired have been produced and identified, whole plants must be generated from them. As yet we do not know if these plants will have the selected characteristics, such as herbicide tolerance, found in the single cell. Apparently the capacity for whole plants to regenerate from single cells is itself inherited. University of Illinois scientists are now incorporating this characteristic into breeding lines of corn and are trying to find or develop the capacity in soybeans. So far soybeans have resisted these attempts.

Transferring characteristics between relatively unrelated species is a potentially great advantage of genetic engineering. Ordinarily it is extremely difficult if not impossible to cross plants that are not very closely related genetically. For example, most of the wild relatives of corn and soybeans in the University of Illinois collection, the largest in the world, cannot be crossed readily with the domesticated crops. Yet some of the wild types have very desirable characteristics. With genetic engineering we hope to make these genes available for producing new crop varieties.

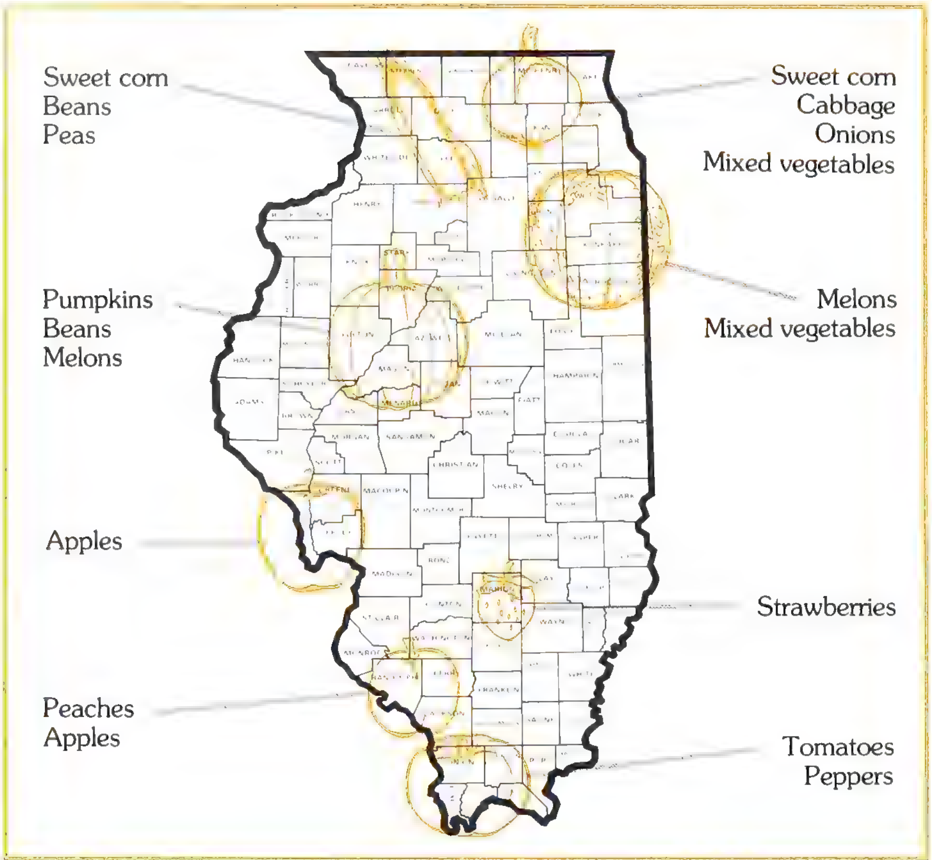
Teams of plant breeders and crop physiologists at the University are currently studying ways to modify nitrogen metabolism, photosynthesis, and other important physiological processes. Our researchers have already demonstrated that the rate of nitrate reduction, a vital biochemical process, can be increased or decreased by standard breeding techniques. In the future, genetic engineering may allow us to modify these processes substantially and thus set the stage for increased productivity and improved quality.

Care must also be given to new and improved uses of crops for food, fuel, chemical feedstocks, and the like. Genetic engineering may make it possible to modify chemical composition and crop quality more rapidly and drastically than was previously possible.

These prospects are very exciting and justify a tremendous increase in our research effort. But we must keep in mind an important lesson found in the history of American agriculture: any major development must go hand in hand with research in several other areas. Exploiting the potential of new crop varieties resulting from genetic engineering will require advances in many other aspects of crop production. New practices may in turn create environmental, economic, and social problems that will demand our attention.

We are stepping into a challenging future. By using our resources effectively, we can make the fruits of basic research available to our own society and to the hungry people of the world.

Donald A. Holt, professor and head, Department of Agronomy



Vegetables for processing and for the fresh market are produced in several areas throughout the state. Orchards are found primarily in southwestern and western Illinois. Farms raising small fruits are scattered in various locations.

Fruits and Vegetables in Soybean Country

John M. Gerber

Casual visitors to Illinois are often mesmerized by the seemingly endless plains of black soil blanketed with characterless expanses of corn and soybeans. Even the rolling countryside of the north or the hilly, forested regions in the south fail to subdue impressions of mile upon mile of grain.

But adventuresome motorists who leave the interstate highways in central Illinois may see bright orange pumpkins flying from harvest machinery into trucks waiting to take them off to processing plants. Visitors to southern Illinois may find hundreds of people on a Sunday afternoon picking juicy strawberries or glistening blackberries. And in northern Illinois the fragrant onion harvest would drive anyone to tears.

Many Illinoisans buy fresh fruits and vegetables at roadside stands and community markets. Yet most residents are unaware that their state is the nation's leading producer of pie pumpkin, horseradish, and onion sets. Serving an important need, fruit and vegetable producers throughout Illinois supply fresh produce to local stores and canned vegetables to the nation (see map).

Horticultural food crops allow farmers to diversify and thus lend financial stability to their operations. Without successful growers, Illinois residents would have almost no farm-fresh produce, and consumers nationwide would see a decline in the availability and a rise in the price of the processed product.

Vegetables for processing. As a major supplier of processed vegetables, Illinois ranks seventh in the nation. On approximately 100,000 acres (40,000 hectares), we produce large quantities of sweet corn, green beans, peas, and pumpkin, along with smaller amounts of tomatoes and asparagus. While making a profit for themselves, growers who raise vegetables for processing try to supply high quality canned or frozen products at a reasonable price to consumers. Unfortunately, continuous battles with insects, weeds, and diseases are profit eaters.

Much of the research on vegetable crops at the Illinois Agricultural Experiment Station focuses on minimizing the use of expensive agricultural chemicals. One example illustrates the point. During a 1980 epidemic of squash bugs (*Anasa tristis*), the available insecticides proved ineffective in central Illinois pumpkin fields. Squash bugs fed voraciously in some of the 5,000 acres (2,000 ha) where pumpkins are grown in the state. To make matters worse, hordes of the bugs invaded communities near the fields.

Working over the next two years, research scientists finally found a safe and effective pesticide that reduced the bug population and may have saved the Illinois pumpkin industry. Continuing studies of *A. tristis* are helping us determine points in the life cycle of the pest when insecticide sprays are most effective. Timeliness of application means that less insecticide will have to be used.

But pesticides don't necessarily solve every problem. For example, a disease outbreak in the 50,000 acres (20,000 ha) of sweet corn grown for canning required another solution. During 1979 and 1980, serious outbreaks of maize dwarf mosaic virus (MDMV) resulted in stunted plants and major yield losses. Because the source of the virus was unknown at the time, little could be done to prevent its recurrence.

Subsequent research revealed that the virus does not live through the winter in northern Illinois. Rather, MDMV is most likely brought in each year by aphids and possibly other insects blown north with the

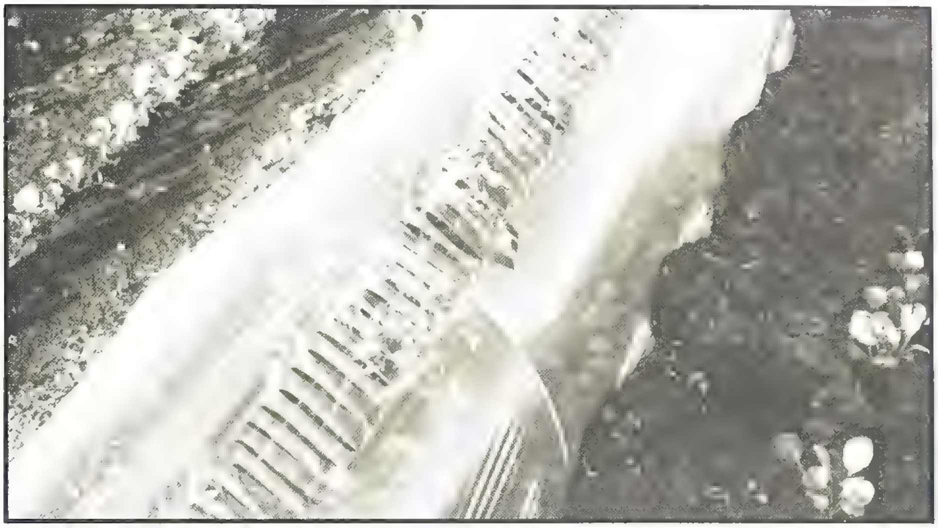
winds. Since aphid control is expensive, plant breeders have incorporated MDMV resistance from field corn into new sweet corn varieties, thus eliminating the need for chemical insect control.

Tomato growers are also benefiting from Experiment Station research now that increased transportation costs have once again made midwestern tomato products competitive with those from California. Tomatoes grow well and can be planted early on Illinois's irrigated sandy soils, which warm quickly in the spring. Furthermore, good drainage allows heavy harvest machinery to move across fields shortly after a rain. But sandy soils have some drawbacks: they are naturally infertile, and soluble nutrients tend to be leached out rapidly by rainfall and irrigation.

The amount and timing of nitrogen fertilizer application is critical for tomatoes used for processing. With the mechanical harvesters of today, all the tomatoes have to be red ripe and still attached to the plant at harvest time. When too much nitrogen extends the ripening period, many tomatoes may still be green and therefore unusable at harvest. On the other hand, with too little nitrogen the plants are weak and the yields low. Researchers have found that several small nitrogen applications are better than a single large one before planting. Small applications not only allow the most efficient use of fertilizer, but also reduce nitrogen losses to groundwater.

Roadside markets give consumers from cities and towns access to farm-fresh produce.

Off the beaten track, pumpkin fields like this one near Princeville, Illinois, supply much of the nation's processed pumpkin for pies.



Plastic tunnels surrounding young plants capture warmth from the sun. The device allows tomatoes, muskmelons, and peppers to be planted early. Intercropping of faster growing vegetables such as collard greens permits intensive production.

Vegetables for the fresh market. Fresh produce is available to consumers at roadside stands and farmers' markets throughout the state. For many consumers, trips to roadside stands are no longer merely part of an occasional weekend drive in the country. Sweet corn, tomatoes, and peas grown locally are sought after on a regular basis for their quality, freshness, and reasonable price. People concerned with both nutrition and freshness have found local farm products to be far superior to those shipped from the South and West.

The sale of locally grown produce is no longer limited to roadside markets, however. Large food chains have recently increased their displays of vegetables purchased from nearby farms. Farms near St. Louis and Chicago lead the state in the production of sweet corn and to a lesser extent cabbage and onions, followed by tomatoes, peppers, snap beans, and jack-o-lantern pumpkins.

The flavor of sweet corn has been improved by an exciting advance in plant breeding (see box). New "extra sweet" genes developed at the University of Illinois have been used to produce hybrids with more sugar than standard varieties contain. For the present, however, these new types will have limited use in commercial operations until yields and disease resistance can be improved.

Early summer vegetables such as tomatoes, cucumbers, peppers, and zucchini are grown in the hills of southern Illinois. Most of the farms there are relatively small and rely on a premium quality product to find a place in the market. Earliness is critical since market prices are usually higher in spring and early summer before northern crops are harvested.

Experiments on drip irrigation, plastic mulches, and other intensive production practices have resulted in significant advances in earliness and total yield of several vegetables. Supported by wire hoops, clear plastic tunnels placed over rows of vegetables can trap solar energy for warmth and can protect young crops from drying winds. Experiments in

Sweet (Sweeter, Sweetest) Corn

David B. Dickinson and Ashby M. Rhodes

Sweet corn — a favorite of many people — is an important crop in Illinois. Improving its tenderness and sweetness is therefore a major goal of our sweet corn research. Extra-sweet varieties have been available for about twenty years. Unfortunately, they lack the creaminess typical of ordinary sweet corn because they contain no phytoglycogen, a water-soluble form of starch.

That problem is on the verge of being resolved, however. Several years ago we crossed an exotic, South American flour corn with high quality inbreds of ordinary sweet corn. Daughter lines were established in hopes of creating a more varied and useful group of inbreds. One of the inbreds, Illinois 677a, was much sweeter and more tender than the others, because the kernels had about twice as much sucrose (sugar) as the ordinary varieties. We were pleasantly surprised to find that these extra-sweet kernels are also creamy and contain normal amounts of phytoglycogen.

Taking the research still further, our group showed that the high sucrose content is due to a single gene, which has been named "sugary enhancer." This enhancer gene works in combination with the sugary gene found in ordinary sweet corn.

Sugary enhancer has now been transferred from Illinois 677a into other sweet corn inbreds. Eleven of them were recently released to the public, and several hybrid varieties of sugary enhancer corn are available through commercial outlets. In the future, new and improved varieties can be expected as plant breeders work for better seed germination, pest resistance, and productivity.

The new sugary enhancer varieties hold an important advantage over the older extra-sweet varieties. In a field or garden planted with several different varieties, some cross-pollination is common. When it occurs between the older extra-sweet varieties and ordinary sweet corn, the flavor suffers because all kernels with mixed parentage are starchy and not at all sweet. But now, when pollen from ordinary sweet varieties crosses with the new sugary enhancer corn, the kernels with mixed parentage are either midway in sweetness between the two parents or have the sweetness of ordinary sugary corn. A sprinkling of these kernels on an ear does not affect the flavor.

To take full advantage of the new trait will require still more fundamental research. As yet we don't know which chromosome carries the sugary enhancer gene. Several other questions need answers. For example, which enzyme or enzymes are altered to cause the accumulation of sucrose? Why does the enhancer gene improve the action of the sugary gene but have no effect when bred into starchy field corn varieties?

Research related to these questions should help us improve sweet corn varieties. The information gained should also aid our understanding of how starch accumulation is regulated and should be helpful to researchers working on the improvement of field corn.

David B. Dickinson, professor of plant physiology; Ashby M. Rhodes, professor emeritus of plant genetics

intercropping have shown that collard greens can be grown between rows of muskmelons, tomatoes, or peppers, thus helping to defray the cost of plastic mulches and increase production where land is limited. Research on new cultural systems of intensive production will benefit not only small farms in Illinois, but may also prove useful in less developed countries.

Fruit crops. Apples are the major tree fruit grown in this state. Most of the orchards are located in southwestern and western Illinois. The apples picked there are shipped to midwestern cities before other, more northern regions are in production. In recent years, the apple industry has developed pick-your-own orchards in the central and northern parts of the state.

Since ladders are required to harvest apples from standard-sized trees, most of the pick-your-own operations use dwarf trees, thus eliminating the need for ladders. Rootstocks from around the world are being used in research to develop dwarf but otherwise healthy, productive trees.

As the number of small apple orchards in Illinois increases and direct sales to consumers rise, research on disease resistance is becoming more important. Part-time orchardists are less likely than full-time growers to stick to the rigid spray schedules required to produce fruit that is free of apple scab. After many years of plant breeding research at the Experiment Station, the first scab-resistant varieties have been released. In 1979 the variety 'Jonafree', a 'Jonathan' type apple, was made available, followed two years later by a 'Red Delicious' type named 'Redfree'.

Our research will significantly reduce the need for costly pesticide applications to apple trees, as more and better cultivars become available. With pioneering efforts in tissue culture and genetic engineering, advances in this area will be much quicker than with traditional plant breeding.

Major changes in the Illinois strawberry industry have been made pos-

sible by improved cultivars and marketing strategies. In the 1950s, strawberries for shipping to wholesale markets were grown on nearly 3,000 acres (more than 1,000 ha) of Illinois land. By 1976, fewer than 1,000 acres (400 ha) were in production because of competition from the large, fresh strawberries being shipped from California. Recently, however, the strawberry has made a comeback, thanks to thousands of residents of Illinois and surrounding states who have discovered the enjoyment of picking their own berries. Surveys of consumer buying practices have helped strawberry growers tailor their advertising and marketing strategies to the demand.

New varieties resistant to the devastating red stele disease now produce high yields of luscious berries. In the past, growers farming on a small scale seldom had enough suitable land that was free of verticillium wilt, a disease affecting strawberries, as well as tomatoes, peppers, and potatoes. New varieties are resistant to the disease, produce larger berries, and have better yields.

Development of a thornless blackberry for northern climates is one of the most promising research advances among the small fruits. With plant breeding and tissue culture techniques, we want to change the image of the blackberry from that of a southern plant to that of one which can withstand colder winters. From a single plant that survived the harsh winter of 1982, researchers hope to develop blackberries that are more cold hardy than the standard varieties. Also under investigation are other sources of cold hardiness that eventually may result in a good quality, winter-hardy variety with high yields.

The thorny nature of blackberries has limited their use on pick-your-own farms. Tissue culture techniques, which are used to grow entire plants from just a few cells of the mother plant, have allowed scientists to remove the thorns from some blackberries. The varieties being tested today are not only thornless, but they also outyield the old varieties by more than tenfold. A new taste treat for consumers may be in the offing when these qualities are finally combined with winter hardiness. If the research is successful, northern states may one day see the birth of a new blackberry industry.

Illinois farmers are taking advantage of new opportunities for fruit and vegetable production, and the Department of Horticulture is helping them to do so. As shipping costs escalate and consumer interest in fresh, wholesome food rises, produce grown in Illinois is becoming competitive with produce from the South and West. Some of the world's best soils are right here in Illinois. We also have the necessary water, premier farmers, and proximity to large population centers. For these reasons, Illinois promises to emerge as a major producer of fresh fruits and vegetables in the coming years.

John M. Gerber, assistant professor of horticulture. The section on fruit crops was written with the assistance of Robert M. Skirvin, associate professor of horticulture.

Pick-your-own berry farms are part of an improved marketing strategy that has helped boost the state's strawberry industry in recent years.

Pest Control: New Strategies in an Age-Old Battle

Malcolm C. Shurtleff

All plants, wild and cultivated alike, have been afflicted with diseases, insects, and other maladies since the dawn of recorded history. Religious writings and other early records contain references to locusts, worms, weeds, blights, rusts, mildews, smuts, and rats. Ancient peoples usually attributed these misfortunes to the wrath or disfavor of their gods.

With the birth of the modern biological sciences about a hundred years ago, the doctrine of spontaneous generation was firmly and finally put to rest. This theory held that living matter may originate spontaneously from nonliving matter. Although the theory was unexplained, maggots developing in decaying flesh and mold growing on vegetables were thought to be the direct products of putrefaction.

Through fossil and other records, scientists know that crop pests have been coevolving over millions of years with their host plants. Our understanding of pests and their life cycles is relatively recent, however. Using this new knowledge, entomologists, weed scientists, and plant pathologists can identify one or more vulnerable points in these cycles when each pest can be controlled cheaply and effectively.

Pests and yield loss. Crop pests of all sorts reduce yields and lower the quality of harvested food, feed, and fiber. As yet, though, no one has accurately determined the magnitude of crop losses due to pests; all we have are rough estimates. Generally it is believed that plant pests alone destroy from 33 to 45 percent of the food, feed, and fiber supply produced worldwide each year.

Up to 50 percent of the potential supply may be lost in regions such as North America and Western Europe, where relatively intensive control measures are used. In developing countries, losses before and after harvest may reach 80 percent or more. Many of these countries do not have access to modern technology, and they lack adequate storage facilities. In the Philippines, for example, rats consume 50 percent of all stored grains and their products, causing losses greater than those from all other pests combined. Our nation and the world cannot continue to sustain these losses without serious consequences.

Control methods. Crop pests are controlled by five basic methods: regulatory, cultural, biological, physical, and chemical.

• *Regulatory* methods include plant quarantines, embargoes, and inspections, as well as certification and indexing programs.

• *Cultural* controls involve sanitary measures such as turning under crop residues, roguing undesirable plants, and rotating crops; proper planting, fertilizing, cultivating, pruning, watering, and harvesting; and controlling humidity and temperature in transit and during storage.

• *Biological* methods include the development and use of genetically resistant species and cultivars; the release of pest predators and parasites; the development of toxins, phytoalexins (compounds formed in response to disease and other stress factors), and antibiotics; and the timely use of behavior-modifying substances such as pheromones. Genetic engineering promises to open new avenues for the biological manipulation of crops and their pests.

• *Physical* controls include water management and the use of refrigeration and dry or moist heat to treat seed, other propagative plant parts, and the soil.

• *Chemical* methods involve the application of chemicals to the soil, plant foliage, reproductive plant parts, harvested products, and storage areas.

Each year the United States spends about $4 billion on some 1.4 billion pounds of pesticides, more than half of which are used by agriculture and forestry. At today's prices, the annual cost of damage to U.S. crops plus the pesticides applied for control is probably $20 billion.

Many crops, especially fruits and vegetables, are extremely vulnerable to diseases and insects. Entire crops would be destroyed if natural controls were to fail, if a pesticide-resistant strain were to emerge, or if a new pest or race were suddenly to appear.

IPM. Integrated pest management (IPM) is an interdisciplinary approach to pest control. It involves the development, evaluation, and implementation of strategies that take maximum advantage of all control methods applied singly or in combination. The wise use of IPM will minimize any adverse effects on humans, crop plants, and the environment.

IPM aims to regulate and stabilize rather than eliminate pest populations. Successful control must be tailored to all pests occurring in a particular region and the relative importance of each pest. We need detailed studies of population dynamics for all types of pests under a wide range of conditions. Studies of one or two pests in a controlled, artificial environment are not enough.

The pest population level at which control measures become economically worthwhile is known as the economic threshold. At present we know the thresholds for relatively few insects and diseases; we do not know the thresholds for any pest complexes. Economic thresholds vary with individual producers, who must determine their expected crop revenue, type of pest and its population size, control costs, stage of crop development when attacked, crop management practices, and climatic conditions.

Integrated pest management rests on a solid definition of economic thresholds for the key pests of our crops. Improved IPM programs also require the ability to predict the size and frequency of infestations and the financial risks associated with various control decisions.

Social concerns. The world's population is increasing by almost 150 people each minute of every day. By the year 2000 — only seventeen short years away — the projected population will be close to 6.5 billion people, an increase of 50 percent between now and then. The great majority of these people will live in desperately poor developing countries that in 1983 can barely feed themselves. Today, one-eighth to one-fourth of the earth's population is hungry and malnourished, and the problem is getting worse. What will it be in the year 2000?

Ways must be found to stabilize the world's supply of food, feed, and fiber. Better control of harmful crop pests will certainly help to alleviate the problem. In the past, the profligate use of pesticides in agriculture has had some unfortunate results. Nevertheless, insecticides provide the most reliable and immediate means available at present for suppressing outbreaks of insects and mites. Herbicides, too, are an important means of protecting crops and are gradually replacing hand labor for controlling weeds. Chemicals will continue to be a necessary and beneficial control measure, but only if they are used wisely.

Over the next ten to twenty years or more we need to develop and implement a truly integrative, ecological approach to pest control. Compared with current methods that depend on extensive use of chemicals, IPM will provide adequate protection, be less costly, and present fewer dangers to human and animal health and to the environment.

This goal can be achieved only if budgets from state, federal, and private sources are greatly expanded. Increased funding is necessary to cover both basic and applied research on crop protection and to disseminate the findings to those who grow our crops. We must remember that all the food and feed consumed and much of our fiber come either directly or indirectly from crops.

The Illinois Agricultural Experiment Station and other universities in the land-grant system have been instrumental in developing the crop protection practices in use today. In

the sections that follow, the authors discuss some of the research projects that will enable us in the years ahead to achieve still greater control over insect, weed, and disease pests.

Malcolm C. Shurtleff, professor of plant pathology

Insects

Marcos Kogan

Thousands of insect species feed on plants in Illinois, but only a few of them are agricultural pests. A species becomes a pest when the population exceeds the economic injury level. Insects thrive in the typical Illinois agroecosystem consisting of corn and soybean fields, the grassy borders surrounding them, weedy ditch banks, woodlots strung along rivers, and fields of alfalfa and other forage crops.

Entomologists have assembled an impressive body of information on the biology and behavior of the major insects attacking our crops, especially corn, soybeans, and alfalfa. Adequate integrated pest management systems (IPM) are now available for rootworms, cutworms, and European corn borer in corn; major defoliators in soybeans; and the alfalfa weevil in alfalfa.

Neither IPM nor the pest situation is static. An aggressive research program is therefore essential to improve existing systems and solve new problems that constantly arise. Many entomological research projects are in progress at the Illinois Agricultural Experiment Station and the Illinois Natural History Survey. The examples that follow highlight a few of the developments.

Corn. Counting the rootworm beetle population in corn helps us assess the probability of injury to the crop during the next growing season. Obtaining accurate measurements is a problem, however. Now being tested, a new trap for capturing the beetles promises to be very effective in monitoring the rootworm population (Fig. 1).

The trap is baited with cucurbitacin, a bitter compound with an arresting effect found in squash. Rootworm beetles are attracted to the compound and will not leave a location as long as it is present. Traps containing powdered squash laced with an insecticide are placed behind the leaf sheaves of corn and similar sites where the beetles prefer to hide and rest. Once inside the trap, the insects are killed by the insecticide and can be counted easily.

Fig. 1. Corn rootworm trap, made from a plastic medicine vial drilled with ten holes. The trap, baited with powdered squash high in cucurbitacin to attract beetles, contains an insecticide.

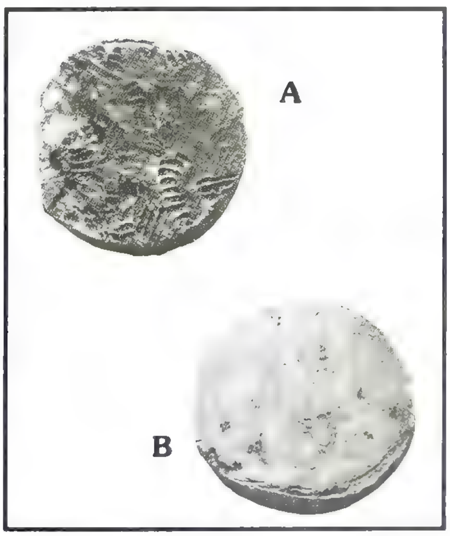


Fig. 2. Mexican bean beetle feeding preferences. (**A**) Untreated soybean cotyledon shows feeding ridges. (**B**) Cotyledon treated to produce high concentration of phytoalexin shows lack of feeding.

Soybeans. Although soybeans can generally tolerate moderate defoliation, dense populations of defoliators may cause substantial yield losses. Increasing the crop's natural defense against defoliators such as the Mexican bean beetle is therefore a highly desirable component of an IPM system. Accordingly, we have obtained soybean lines with moderate levels of resistance and good agronomic characteristics for use in breeding programs at Illinois.

We have also been trying to shed light on the mechanisms of resistance and chemical factors related to them. Recent research in our laboratories suggests that phytoalexins (plant compounds formed in response to disease and other stress factors) may inhibit feeding by the Mexican bean beetle (Fig. 2). These studies expand our understanding of mechanisms that regulate the interactions of insects and plants.

Alfalfa. Insects and other pests significantly reduce the productivity and longevity of alfalfa. The crop can sustain some injury without a significant loss in yield or quality. Beyond a certain level, however, control of pests is necessary in Illinois. With effective management of these pests, we hope to extend alfalfa longevity beyond the usual three to five years, reduce the energy required for establishing the crop, and increase its productivity.

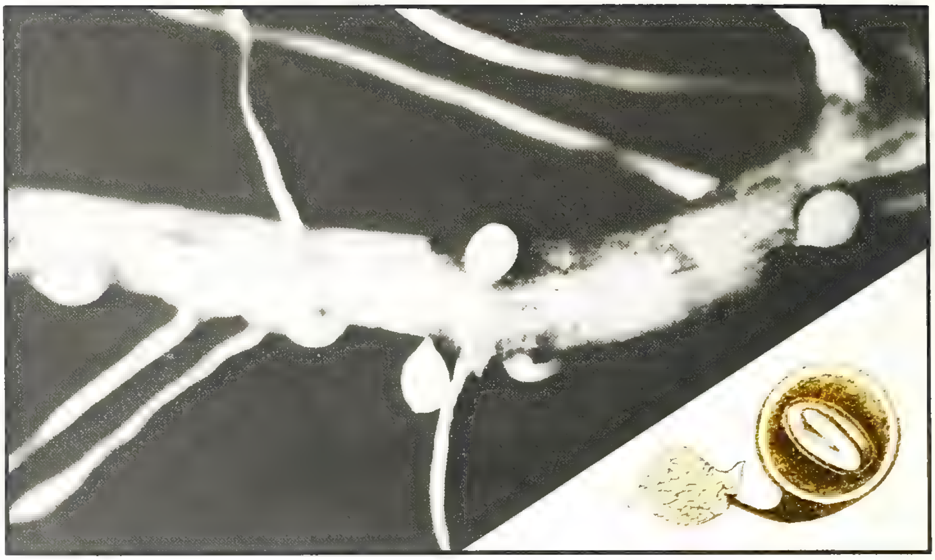
We have now developed an IPM program for the alfalfa weevil, which can seriously injure the first crop of the season. The program takes into account the presence of parasites, recommends cultural control procedures, and helps growers predict when to apply pesticides.

The potato leafhopper can be a serious problem on the second and third crops. Research on its control is under way, and we are trying to develop tactics that can be integrated with the existing alfalfa weevil system. Control of weeds and plant pathogens related to leafhopper activity will also be incorporated into the IPM system.

Marcos Kogan, entomologist, Illinois Natural History Survey, and professor of agricultural entomology

Malcolm C. Shurtleff

Plant diseases are numbered in the tens of thousands. Without natural defenses against invading organisms, wild and cultivated plants could not survive. Occasionally, however, a disease seriously injures a crop, and yields decline drastically. To understand diseases and develop effective controls, plant pathologists at the University of Illinois are now engaged in 28 research projects. Two of them, described briefly in this article, are aimed at finding practical and economical controls for the soybean cyst nematode and for some diseases that afflict corn.



Soybean cyst nematodes on soybean root. The cysts are filled with eggs (insert). Each viable egg contains a fully developed second-stage larva.

SCN. The soybean cyst nematode (SCN) has now invaded parts of 22 states, including 67 counties in Illinois. If conditions are right, up to 80 percent of the yield can be lost. The size of the nematode population and the presence of other diseases can spell disaster, especially when soil type and fertility, weather conditions, and cropping sequence favor the reproduction of SCN.

Several control measures are available, but they should be integrated with one another for the best results. Once SCN has been identified, the predominant race should be determined. An economic analysis of control alternatives can then be made to help producers select control strategies for their particular farm.

Each year that a nonhost crop such as corn, sorghum, red clover, or alfalfa is planted, nematode populations are reduced 50 to 90 percent. Normally after three years, a susceptible soybean variety can again be planted. High yielding, resistant varieties developed by breeders on the University of Illinois campus are available for the southern two-thirds of the state. These varieties are resistant only to specific races, however. Since the races are mixed, continuous planting of one resistant variety encourages large populations of other races.

Several of the many nematicides tested in the past fifteen years are now recommended. They are applied as granules in bands over the row or in the planting furrow. In general, nematicides should be considered only where adapted, resistant varieties are unavailable or where crop rotations are impractical. Nematicides will probably also be necessary when susceptible varieties are planted and SCN populations exceed the threshold of 20 viable eggs and larvae per 100 cubic centimeters of soil.

Before a susceptible variety is planted, the soil should be analyzed to determine the population level of SCN. If it is below the threshold, a susceptible soybean variety can be planted without nematicide protection. To successfully control SCN, all control strategies should be used. Once introduced into a field, SCN can't be eliminated, but it can be managed so that it is economically unimportant.

When resistant varieties are planted, the crop must be well fertilized to obtain optimal yields and to realize the full potential of a nematicide. All equipment used in infested fields should be thoroughly washed before moving it to noninfested fields. Before planting, seeds from infested areas must be passed through a spiral cleaner to eliminate nematodes carried in peds mixed with seeds.

Corn diseases. Since 1970, the corn-blight year, we have witnessed changes in the diseases attacking corn in Illinois. We have seen outbreaks of eyespot; yellow leaf blight; anthracnose leaf blight, top-dieback, and stalk rot; race O of southern corn leaf blight; the appearance of two new races of northern corn leaf blight; gray leaf spot; Goss's bacterial wilt and blight; and maize chlorotic dwarf. The identification of nematodes as important corn pathogens in Illinois is also recent.

Plant pathologists at the University of Illinois have concentrated on monitoring where these diseases occur, identifying sources of resistance, and understanding their inheritance. Searching for disease-resistant genes and incorporating them into commercial inbreds are never-ending projects, because new pathogens and races are constantly evolving. We are also trying to understand how new, virulent races develop and the mode of pathogenicity in an effort to find new control strategies.

More precise yield loss information can be formulated from studies of the interaction between plant pathogens and insects, epidemiology, and crop development models. Continuing research on chemical control of leaf and seed pathogens and nematodes has resulted in more efficient use of chemicals on farms and in seed production fields.

Malcolm C. Shurtleff, professor of plant pathology

Soybean variety trials. Resistant variety is to the left, susceptible varieties are in the foreground, and plot treated with a nematicide is in the background.

Anthracnose stalk rot of corn.

Corn leaves with blotches characteristic of Helminthosporium leaf blight.

Nematode damage in a corn field.

Weeds

Fred W. Slife

Unwanted plants have always plagued agriculture. Even today in many countries of the world, more human labor is expended on weeding fields than on any other agricultural task. For several thousand years, there were few changes in weed control methods, but in the last forty years some major changes have taken place.

Selective herbicides were introduced in the 1940s. The continuing development of new herbicides since then has led us into a period of remarkable control of weeds in most crops. When used judiciously, herbicides combined with good management practices are superior to other control techniques.

Weed science research in Illinois is a cooperative effort between the U.S. Department of Agriculture and scientists in the Departments of Agricultural Engineering, Agronomy, and Horticulture. A few of the many research activities under investigation are discussed here.

Reduced tillage. Almost all Illinois farmers now practice some form of reduced tillage to control erosion. Unfortunately, this practice conflicts directly with preplant incorporation of herbicides, our most widely used method of weed control. Current research is divided into two major areas: (1) determining those reduced tillage systems that are compatible with current weed control practices, and (2) developing new control practices that are compatible with various reduced tillage systems. Newly designed incorporation tools that leave more crop residues on the surface are under evaluation, and fall herbicide incorporation is being compared with spring application.

Pesticide equipment. The technology of pesticide application hasn't changed much in the past thirty years, but current research may soon lead to some important innovations. For example, we are investigating very low volume application that uses only a small quantity

of surfactant instead of water. The surfactant may be petroleum based, but could be soybean or other vegetable oils. Compared with conventional sprayers, several new ones can more effectively control droplet size and hence reduce the drift potential. Some of these new devices place an electrostatic charge on the spray particles, thereby allowing more pesticide to be applied to plants after emergence.

Herbicides on minor crops. During the past ten years considerable progress has been made in obtaining registration of new herbicides for crops growing on limited acreage. The data required for registration are generated by interregional committees composed of University of Illinois and U.S. Department of Agriculture scientists working in cooperation with the pesticide industry. In Illinois, herbicides and insecticides are now registered for use on our onion, horseradish, and pumpkin crops, as well as for hundreds of ornamentals.

Biology and competition. Oddly enough, we may have been too successful in controlling our most troublesome weeds. With less competition, other weed species that are not well controlled can now become dominant within a few years. For example, black nightshade has suddenly emerged as a major problem. In addition to studying black nightshade's competitive effects on soybean yields, we are researching in detail its life cycle to identify the environmental conditions that are conducive to seed germination and growth. The findings will help us determine when control measures, either chemical or cultural, will be needed.

We are also studying the biology of two newer weeds, a northern strain of johnsongrass and wild proso millet, a recent introduction into the United States. Both species have been found in the northern half of Illinois in the past few years. A thorough understanding of their growth characteristics may help us eliminate them before they cover large areas.

Fate of herbicides in plants and soils. One continuing research objective is to determine which plant functions are impaired after herbicide application. This research gives us a much better understanding of metabolic functions in plants and may lead to even more effective herbicides in the future.

The second objective of these studies is to examine the rate at which herbicides degrade and the products left in the environment after degradation. The potential for chemical residues in harvested crop plants and for carry-over into the next growing season can be predicted from this work.

Herbicides enable growers to plant corn and soybeans earlier than in the past and thus use the growing season to greater advantage. As reduced tillage alters the weed spectrum, new herbicides will be needed to control perennial weeds and to prevent the development of herbicide-resistant weeds. In the immediate future, herbicide use will probably increase because of reduced tillage systems. Despite the tremendous success of herbicides, however, alternative measures are needed to lessen our dependence on chemicals. Biological control is one possibility, and recent work in this area is encouraging.

Fred W. Slife, professor of crop production

Crops, Stress, and Genetic Improvement

John S. Boyer

Farmers are constantly hunting for ways to cut costs while increasing yields. One effective way of doing so is to use relatively cheap, genetically superior plant types and to conserve high-priced inputs such as water and nutrients. For this strategy to work, however, the plants selected must acquire nutrients efficiently and suffer little from occasional periods of water deficiency. The search is on for genotypes with these traits.

Yield improvement. During the last fifty years, revolutionary changes have taken place in the production of grain crops. The adoption of hybrid corn between 1935 and 1955 followed by an upsurge in nitrogen use account for most of the yield increases in corn (Fig. 1A). In soybeans, improved cultivars and effective weed and disease control have contributed the most to rising yields.

From the farmer's standpoint, improved genetic material is generally cheaper than nutrients, pesticides, and other inputs. Therefore, we want to see that genetically improved seeds reach the market as quickly as possible and that producers are acquainted with their potential.

Just how much has genetic improvement, rather than changes in cultural practices, contributed to yield increases? To answer this question, scientists in the Departments of Agronomy and Botany raised soybean cultivars popular at various times during the last forty years. The experiment was conducted in a common field, using current management practices to eliminate differences in cultural techniques. This approach allows only genetic effects to influence yield.

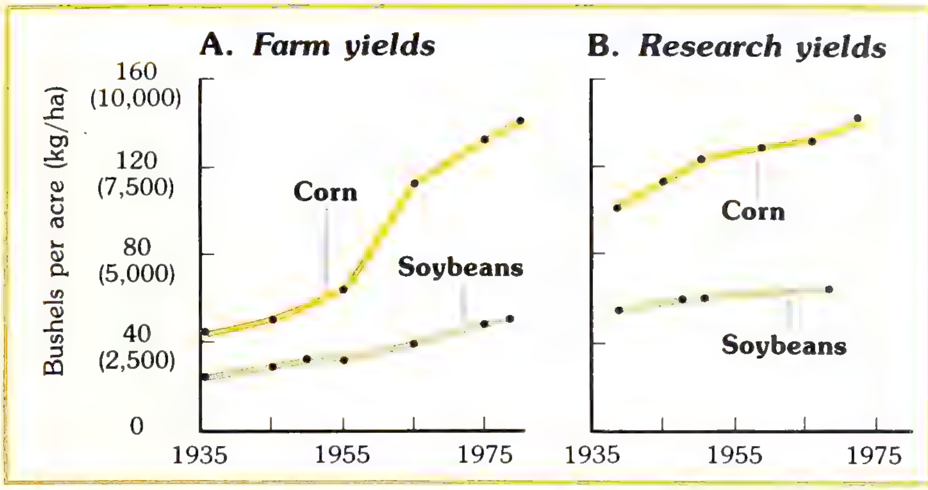


Fig. 1. (**A**) Average farm yields for corn and soybeans in Champaign County, Illinois, 1935 through 1978. In 1935, open-pollinated varieties of corn, rather than hybrids, were common. (**B**) Research yields. Genetic performance of corn hybrids and soybean cultivars released between 1935 and 1970. The soybean cultivars were tested in a single research field in Champaign County, using modern planting densities and cultural techniques; the corn hybrids were similarly tested in Iowa. Newer cultivars yielded more than older ones, demonstrating genetic improvement. The genetic improvement shown in **B** is about 50 percent of the increased farm yields shown in **A**.

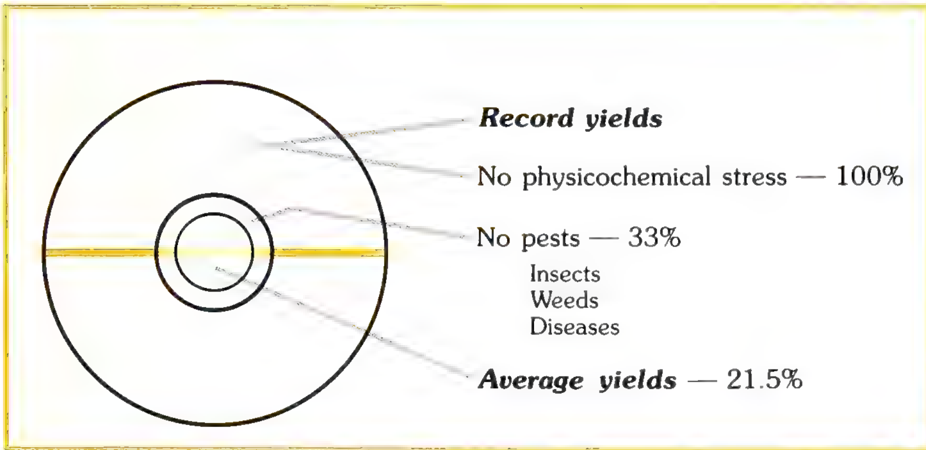


Fig. 2. Effects of physicochemical factors and pests on yields. Record yields, represented by the diameter of the largest circle, are achieved when pests and physicochemical stress have been eliminated. Average yields, represented by the diameter of the smallest circle, are realized on the farm.

Adapted from USDA statistics for eight major crops in the United States.

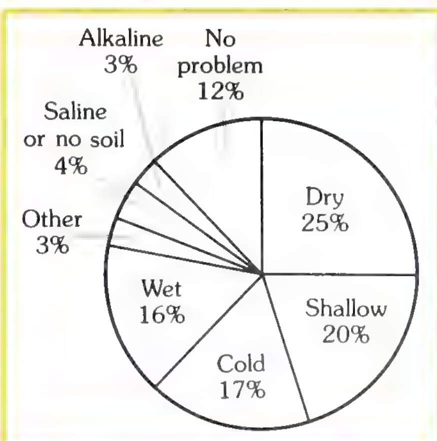


Fig. 3. Percentages of U.S. soils affected by various physicochemical limitations.

Compared with the older soybean cultivars, the modern ones produced higher yields in our study; a similar result was obtained for corn by scientists in Iowa (Fig. 1B). For the forty years in question, our rate of yield increase from genetic improvement alone was half the farmer's rate of yield increase, which indicates that genetic improvement contributed substantially to yield progress on the farm (compare Fig. 1A and 1B). The other half of farm increases resulted from better cultural practices. For farmers, however, the purchase price of cultural inputs is generally greater than the price of genetically improved seed. Clearly, genetic improvement has a part to play in future agriculture.

Record versus average yields. Basically, yields can be increased genetically in two ways. One is to develop cultivars that can take full advantage of nutrients, water, and pest control under the best of conditions. The other is to develop cultivars that perform well even when cultural conditions are less than favorable, as is often the case in the real world. The second approach has been less popular than the first among geneticists, in part because understanding how plants cope with environmental stress is a complex business. Nevertheless, this method holds promise for raising the level of production.

By analyzing record and average yields, we can get some idea of the gains to be made from the second approach. Record yields, which are much larger than average yields, are obtained first of all because the plants can take full advantage of environments that are nearly perfect,

and secondly because pests are adequately controlled (Fig. 2). If we can adapt plants so that they can perform well in environments that are less than perfect, then clearly we will be able to bring average yields closer to the record yields.

Plant stress. Problems with plant stress are common in the United States (Fig. 3). Drought alone affects 25 percent of our soils; another 53 percent are shallow, wet, and cold. Only 12 percent of U.S. soils have few if any physicochemical limitations for crop production.

Drought is a problem occasionally in Illinois, more often in the southern than in the northern part of the state. The statistical likelihood of having significantly lower than average rainfall in a 5-year period is shown in Figure 4. In southern Illinois, precipitation may drop to as little as 56 percent of normal once every 5 years, but it is likely to be 64 percent or more of normal in northern Illinois during the same time.

Stress can also result from an inadequate supply of soil nutrients, which become depleted rapidly when crops are harvested. On the Morrow Plots at the University of Illinois, the soils have virtually no physicochemical limitations, but they do require additional nutrients for maximum production. When no nutrients were added to the plots, modern corn hybrids yielded only 45 bushels per acre, compared with 130 to 140 bushels with some nutrients supplied. Similarly, soybeans yielded 37 bushels per acre without but 48 to 50 bushels with additional nutrients.

Research in progress. Problems due to drought and nitrogen availability, two major facets of agricultural production, are being studied in depth by scientists at the University. It is well known that grain crops are especially vulnerable to drought during flowering and pollination. Starting with this observation, scientists have shown that different parts of the corn plant are sensitive to drought in different ways. Roots, for example, continue to grow rapidly when conditions are dry enough to halt the growth of stems and silks. Along with cessation of growth, silks may become less receptive to pollen growth even though the pollen remains vigorous. We are planning to search for any genetic differences that might protect corn against these problems.

Studies are also under way to explore how plants draw nutrients from the soil. We have learned that drought impedes nitrate uptake in corn, thereby altering the metabolism of nitrate. The overall result is that a crop uses less of the nitrogen applied to the soil. With less nitrogen available to the crop, grain production is inhibited. Yet as the uptake of nitrogen decreases, its concentration in the grain may actually increase. In the case of wheat, changes of this sort can cause problems in bread making.

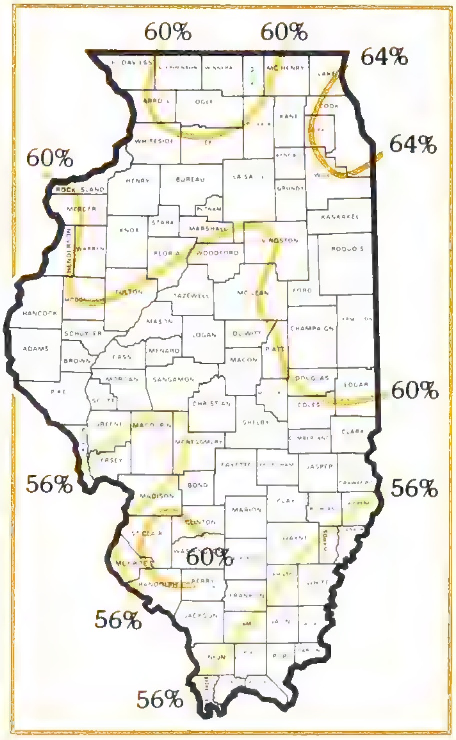


Fig. 4. Average severity of 6-month drought expected during a 5-year period in Illinois. Numbers indicate percentage of normal precipitation during the 6-month drought.

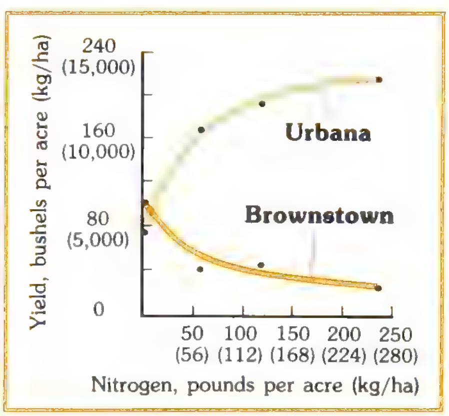


Fig. 5. Grain yield of corn grown with adequate rainfall in Urbana and during a drought in Brownstown, 1976.

Recently we made some other unexpected discoveries. Certain parts of the corn plant such as the roots and leaves began to adapt to dry conditions by accumulating large quantities of metabolites. These tissues are most capable of growing during drought. Stems and silks, the tissues most sensitive to drought, were least able to accumulate metabolites. We hope to explore how this process works and whether it can be altered, particularly by genetic means.

The interaction between nutrient uptake and water stress needs further research as well. When drought occurs, nitrogen recommendations can be frustrating. For example, the 1976 corn yields increased with additional nitrogen in Urbana but decreased in Brownstown (Fig. 5). The main difference between the two sites was that Brownstown had a drought, while Urbana had average rainfalls. Another difference may have been the soil type, which is more drought-prone in southern Illinois than here. The negative effect of added nitrogen in Brownstown that year complicates our understanding of nutrient effects and water stress. As we learn more about the acclimation of plants to dry conditions, the reasons for these nutrient-water interactions should become clearer.

Our goal is to obtain bigger yields under a wide range of environmental conditions. By understanding how plants cope with stress, we hope to provide the basis for realizing that goal. Perhaps the gap between record and average yields can be narrowed by developing genetically improved crops that will not put too much of a strain on the farmer's pocketbook.

John S. Boyer, professor of plant physiology

In Progress

Illini Nutrition Research Goes to Washington

The occasion was the 1983 Agricultural Research Fair. The place was the Caucus Room of the Cannon House Office Building in Washington, D.C. Attendees were members of Congress, the President's Cabinet, diplomatic and USDA staff members, and other dignitaries.

People viewing the Research Fair on May 4 had a first-hand opportunity to learn about the sophisticated side of agricultural research and how it benefits urban residents. The House Committee on Agriculture developed the idea for the Fair to acquaint colleagues, most of them representing few if any rural constituents, with the critical needs being met by agricultural research. The message was that increased funding for research is an excellent use of tax dollars.

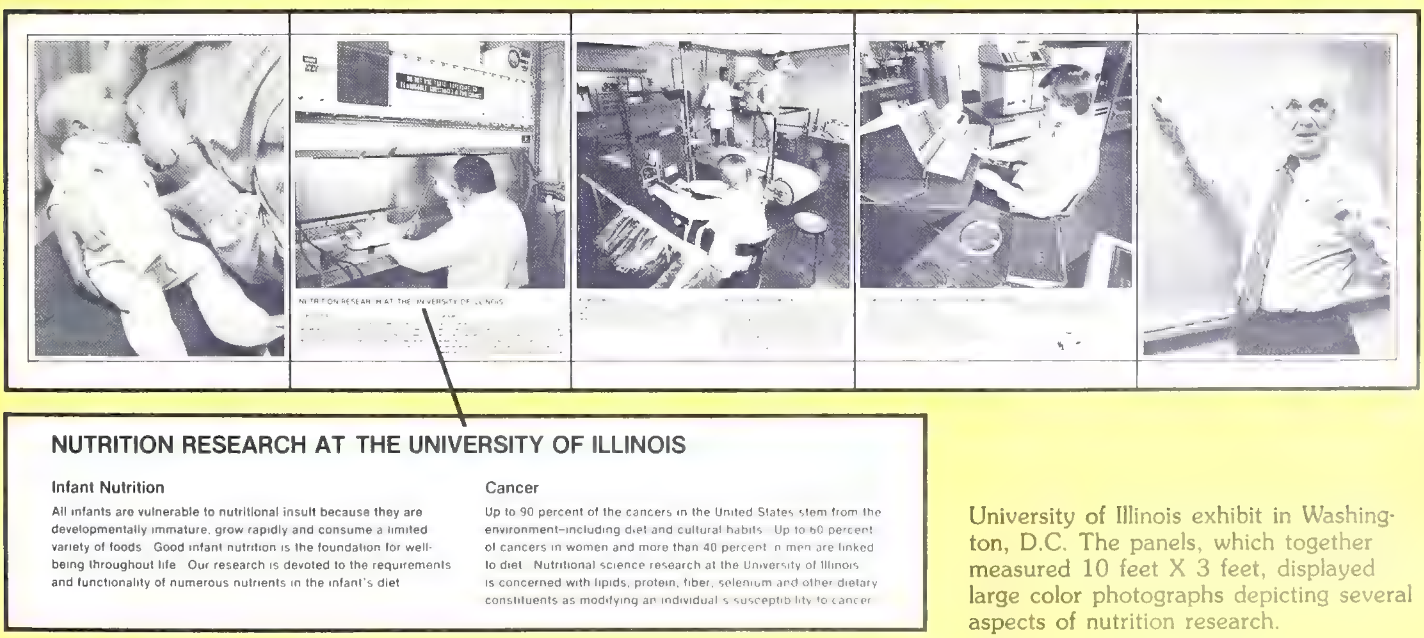
"Partners in Progress," the slogan for the Fair, sums up the cooperative nature of research activities among institutions. Twenty of these groups, consisting of nineteen state experiment stations and the U.S. Department of Agriculture, set up booths in the Caucus Room. Each exhibit portrayed some facet of agriculture that serves the public.

Human nutrition, the theme assigned to our Experiment Station, was a wise choice in light of the outstanding research conducted by faculty at the University of Illinois. Pictured in the display were several of the nation's nutritional concerns. Our display was intended to show the importance of the science of nutrition.

Some nutritional issues currently being examined at the University include

- dietary habits and cancer susceptibility
- nutrient requirements of the infant
- diet and exercise in weight control
- obesity, lipid intake, and cell-mediated immunity
- mineral balance and immune response
- fatty acids and maintenance of cell membranes
- agricultural practices and nutritive content of food
- nutritional deficiencies related to alcohol and drug use
- selenium, phosphorus, and calcium in infant physiology
- the regulation of food intake, including anorexia nervosa
- models for evaluating nutrition education programs

More than fifty faculty members are pursuing nutrition research on our campus. Many of these scientists hold an appointment in the Division of Nutritional Sciences.



University of Illinois exhibit in Washington, D.C. The panels, which together measured 10 feet X 3 feet, displayed large color photographs depicting several aspects of nutrition research.

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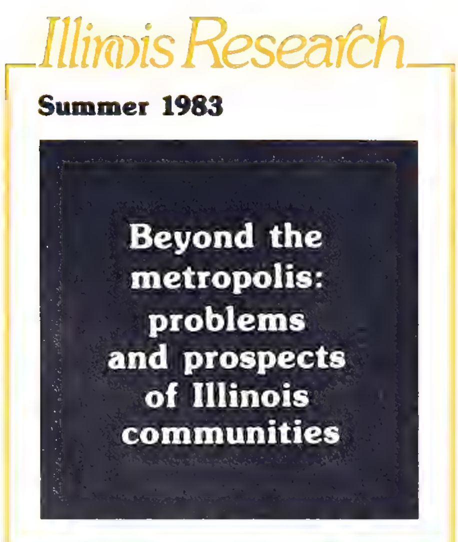

Illinois Research

College of Agriculture, University of Illinois at Urbana-Champaign, Volume 25, Number 3

1983 - Directions - 1993

The Cover

The "little house on the prairie" pictured on the cover is a sign of the changes taking place in nonmetropolitan Illinois. Many small farms have merged with larger ones, but counterbalancing this trend is the sharp increase in the number of mini-farms. Formerly stagnant rural communities have begun to attract young families, urban retirees, and others in search of a congenial place to live. The transportation industry, agribusiness, and governmental units are being pressured by the changing times to meet the needs of residents in rural areas.

Photograph by Larry Baker, *Illinois Research* photographer.

"At a time unlike any in the past, we must envision the future."

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Contents

Letters

To the readers:

In future issues, contributors to *Illinois Research* will discuss advances in plant and animal genetics through biotechnology, chemical feedstocks from biomass, the family, international agriculture, animal production and well-being, and problems related to the weather in Illinois. Our primary objective is to report current research developments in agriculture, veterinary medicine, and human resources and family studies.

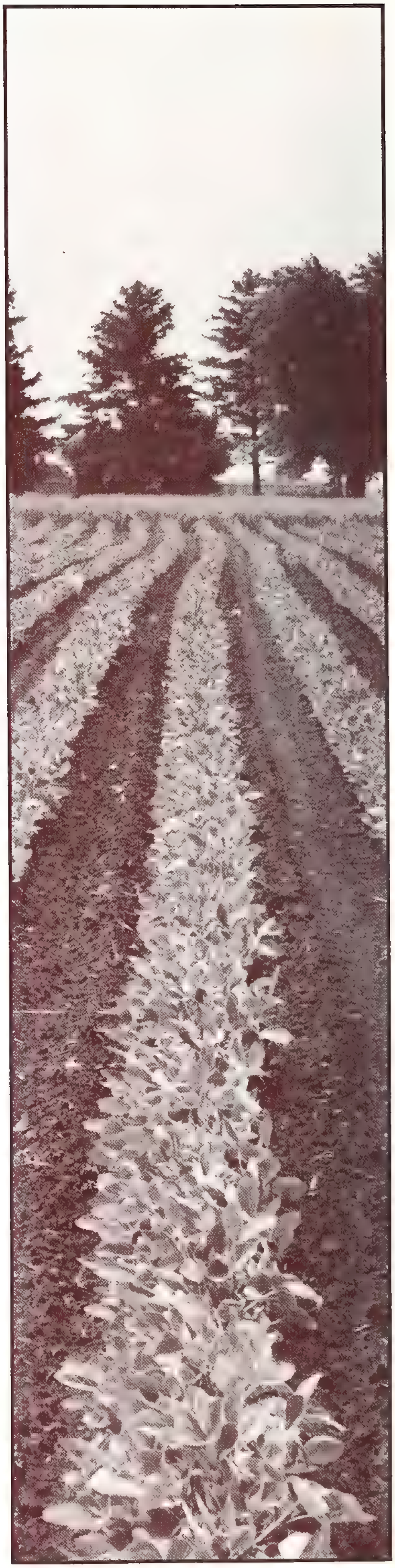
But another important goal is to provide readers an opportunity to make their views known through the "Letters" column. We ask you to raise questions and make comments related to research activities discussed in *Illinois Research*. Since Experiment Station research directly or indirectly affects every Illinois citizen, reader input is one means of helping scientists become aware of vital issues that may need their attention.

Letters to the editor should be relatively brief, legible, and signed. We will select letters for publication on the basis of timeliness, clarity of presentation, and the space available in the column. All sides of an issue will be printed, provided letters meet the criteria for publication.

Sheila A. Ryan, editor

Address communications to Editor, Illinois Research, 47 Mumford Hall, 1301 West Gregory Drive, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801.

Please limit letters to 250 words.



Downstate Illinois

Beyond the Metropolis

Frederick C. Fliegel and J. C. van Es

Beyond the limits of Illinois's major cities, one encounters many different landscapes, places, and people. Public attention tends to be focused on metropolitan areas, and anything outside those areas is vaguely described as nonmetropolitan. What kind of people live out there and what is "nonmet" life like?

For most of this century, downstate Illinois was thought of largely in terms of its family farms, its contribution of young people to the cities, and its coal-rich but often poverty-stricken southern counties. Rural Illinois was considered part of the state's heritage but not terribly vital to events of the day.

Much has changed in just the last decade or two. Although the older images linger on, studies conducted at the University of Illinois are shedding light on the complexity and very substantial vitality of downstate communities. In this article we will try to sketch a profile of today's nonmet against a backdrop of the older, more familiar images.

Farms and farm families. Corn and soybean fields as far as the eye can see, widely scattered farmsteads, and occasional clusters of well-fed livestock are by far the most visible part of our rural landscape. But even casual observers are aware of the drastic reduction in farm numbers during recent decades. Vacant farmhouses and decaying barns are common sights that motorists see when driving from one city to the next.

New housing and other developments are encroaching on farmland

Once part of a small farm, this dilapidated house and hundreds like it now stand empty, victims of the drastic but now stabilized reduction in farm numbers across Illinois.

Construction of new homes along rural roads indicates growing prosperity in many counties.

at the edges of towns and cities, and public concern rises as fertile land is converted to other uses. But in fact the amount of Illinois land in farms has declined only slightly since World War II. In the mid 1970s, farm acreage in production actually increased because of relatively favorable farm prices.

Most of the individual farms that disappeared have merged into larger ones. Although pronounced, this change in the structure of the agricultural industry is not obvious. Larger machines cultivating bigger tracts of land are a sign of these mergers, but only if one has an eye for machines and some notion of what they can do.

Even less visible but no less real is the substitution of machines for human labor and the consequent metamorphosis of farmers into sophisticated managers of business firms. Farm operators may still do some heavy work, but muscle and sweat are no longer hallmarks of success as they were in our grandparents' time.

Another less than obvious fact is the sharp increase in what might be called mini-farms in recent years. Some urban people, but mostly the sons and daughters of the land, have come to prefer life on a small farm while earning a living at some other job. Even as the family farms of yesteryear continue to disappear, small-scale farming is on the rise. As a result, total farm numbers in Illinois have stabilized. Most of the food and fiber is produced by larger farm firms, but farming as a way of life is apparently thriving.

Rural and small town residents. Most of the people in downstate Illinois are not farmers at all. It has been a very long time since the farm population dominated in rural areas. At present, less than 3 percent of Illinoisans live on farms. For every farm resident, five others live outside cities of any kind, large or small. Having no visible connection with agriculture, the nonmets live in small cities and towns or, increasingly, in the open country.

A major change has taken place in people's choice of where to live. Local government officials are acutely aware that some of their towns and counties, which had been losing young people to the cities for many years, have recently begun to grow. Those areas where population is still falling resemble our outdated image of rural life. During the 1970s, 40 Illinois counties that had been losing people to the cities for at least a generation experienced population growth. Most of these counties are in the southern and western parts of the state, areas long perceived to be declining.

Where have the newcomers come from? Although precise figures for Illinois are unavailable, newcomers are arriving, in roughly equal shares, from the big cities and from other rural areas. One can speculate that the movement of urban people to the suburbs in the 1950s and 1960s spilled over into still newer suburbs. The movement then became a flow of people who wanted to get away from metropolitan areas entirely.

It is a fact that many quite remote rural areas have been gaining migrants from the cities; whether the motives that led to suburbanization were transformed into a quest for life away from the cities is speculation. Again, it is a fact that major cities are attracting far fewer rural migrants, but some rural people are migrating to other rural areas that are growing. Here, too, the motives leading to a new migration pattern are a matter of speculation. Unlike their predecessors of an earlier generation, rural migrants today may feel that opportunity beckons from other rural areas, not from the city.

Why are people attracted to formerly stagnant or declining rural areas? Migrants from the major cities are mainly seeking a more congenial place to live. About one-third are retirees, but the majority are younger people, many with children, who want to live in a smaller place, most often in the open country. On the other hand, newcomers from other rural areas most often come to seek jobs. Perhaps the growth spiral that affected cities for such a long time has reappeared as many smaller spirals in the hinterland.

What are some typical traits of today's downstate inhabitants? Accord-

People and Places Left Behind

Andrew J. Sofranko

Amidst the celebration of a new rural America we tend to overlook the persistence of old problems, the emergence of new ones, and the disparity that still exists in the quality of life between rural and urban residents. Differences are obvious in medical and dental care, economic well-being, education, housing, and public transportation.

Put simply, many rural people and communities have not been touched by the rural renaissance. In this sense they continue to be left behind or bypassed. Recent trends in poverty and community growth serve to illustrate the

progress made and the problems remaining for many rural residents and communities in Illinois.

The poor among us. In the twenty years since the rural poor were first identified as part of the "other America," data continue to indicate that poverty is greater in rural than in urban areas. However, poverty has been reduced dramatically among certain segments of the rural population, primarily the elderly and farmers.

In the past, poverty in rural Illinois was a result of an older population left behind when young people moved away. Times have changed, though, with the influx of people into rural areas and with improved social security benefits for the elderly. In the last decade, poverty among the elderly in general has been reduced 12 percent and in rural areas 18 percent. Even so, it is still 3 percent higher outside the urban areas.

The elderly and rural poor made gains in the 1970s, but unfortunately the gains have not solved the poverty problem. The face of poverty is changing. The poor are now less likely to be elderly or farmers, and more likely to be younger people, minorities, or in female-headed families. Poverty related to race and family structure is being described as "the most tenacious in the land."

Rural communities. Illinois is dotted with almost 1,300 small towns, many with strange sounding names like Equality, Fidelity, Wyoming, Cave in Rock, and Paw Paw. Over the past several decades most rural towns have done little more than hold their own, neither growing markedly nor dying as many had predicted. Those close to larger towns and cities or located near major transportation routes of course fared well.

Recently, rural communities have become attractive in the eyes of people throughout the nation and state. Communities with a history of population loss are now growing. In our 34 southern counties, for example, more than 75 percent of the 213 rural communities are expanding, compared with less than 50 percent in the 1970s. Add to this the growth occurring around these communities and one can appreciate the turn of events in rural areas.

Still, many places continue their historical decline. In the case of southern Illinois, 25 percent of the communities are losing people. These communities are off the beaten track, have few scenic or residential attractions, lack access to good transportation or towns, and are underserved by certain types of services. The communities and people of rural Illinois are quite heterogeneous, and efforts to address their problems must be directed at specific people and places that were left behind.

Andrew J. Sofranko, professor of rural sociology

ing to county statistics on poverty, they are better off financially than rural residents used to be. Many live in a rural setting by choice, not because they are stuck there, as once was the case.

The average downstate couple has fewer children than formerly, which is true of the U.S. population as a whole. This situation has led to vacant classrooms in both metropolitan and rural areas. However, as young families with children move in, some of the most rapidly growing southern counties in Illinois are seeing a rise in the school population. Finally, the average downstater is more likely to be white than in the past. As blacks migrated to the cities, whites moved first to the suburbs and now to rural areas at a distance from the cities.

Present and future. Farmland still dominates the downstate landscape, although far fewer people live on farms than in years past. The weather and price fluctuations continue to bedevil farm families, but most now rely on off-farm income to supplement earnings from the farm business. The net result of these major changes is that the farm population is stabilizing, thus putting a halt to the decline of earlier decades.

Compared with a few years ago, many of the state's formerly declining rural areas seem better able to keep their young people and to attract newcomers. The early 1980s have hardly left room for optimism about growth and development, and Illinois as a whole has been hit by stagnation and recession. But any growth taking place in the state is definitely slanted toward the least urbanized areas.

In times past it may have been appropriate to describe large segments of the downstate population as the "people left behind," or more crudely as "bullheads and suckers" left in a fished-out pond. The description is no longer accurate. A turnaround has occurred, not in all areas but in many.

Will rural growth last? Yes, it probably will. There has been a profound shift in where people prefer to live. That shift in preference is not likely to change soon and will probably be reinforced by changes toward decentralization in the economy. But it remains to be seen whether people can act on their preferences. Repeated recessions may well slow down the trend.

In the years ahead, much of downstate Illinois will have to deal with the problems of growth, possibly slow growth. Problems may arise in obtaining the resources to facilitate growth unless the U.S. economy recovers fully. Several problems related to change and growth, or in some cases continuing decline, are discussed in the articles that follow.

Frederick C. Fliegel and J. C. van Es, professors of rural sociology

The Dynamics of Rural Illinois

Harvey J. Schweitzer

Rural Illinois is dominated by hundreds of towns, most of them with fewer than 5,000 inhabitants. In many cases, the economic base and geographical features that attracted early town settlers no longer exist. For example, proximity to railroad lines, streams, or wooded areas is far less important today than a century ago.

To understand nonmetropolitan Illinois, one must recognize the significance of physical space and population density and how these characteristics differ from those in urban areas. Space, along with existing physical resources, provides the setting for the occupations, interactions, and institutions of rural people. Their lives are affected by a host of factors, among them, the distribution of land suitable for various kinds of farming; the presence of coal and oil deposits or forests; location of the streams, waterways, roads, highways, and railroads that traverse rural space; location of towns relative to large population centers; and the boundaries of political entities. Sparse population and the distances between people influence the cost and the kinds of support systems needed to provide social services to rural residents.

Many rural residents who live far from health care facilities have some of their medical problems monitored at clinics held periodically in community centers.

Agriculture-business complex. About 72 percent of Illinois's nearly 36 million acres of land is classified as cropland, compared with roughly 21 percent for the nation as a whole. Production agriculture and the businesses serving it are understandably the dominant industries in rural Illinois.

Predictably, rural communities are profoundly affected by trends in farming and the structure of agriculture. The concentration of farming in the hands of larger operators in Illinois has affected financial institutions, farm machinery and equipment dealers, and suppliers of feed, fertilizer, and farm chemicals.

Small farms are in the picture, too. From 1969 to 1978, Illinois gained about 8,500 farms having fewer than 50 acres. While not contributing substantially to total agricultural production or creating a large demand for agribusiness services, these farms and the families operating them represent a new dimension in many rural communities.

The agricultural community faces a complex of external factors beyond the control of individual producers or businesses. Among the most obvious are inflation, interest rates, export markets, environmental and health regulations, and land use regulations or lack of them. Today's agricultural leadership is challenged to understand these issues and to deal with them within the context of an urban society.

One must not overlook other important rural industries, namely, mining, forestry, recreation and tourism, and a great variety of manufacturing, utility, and service companies that provide employment in rural communities. The potential for expansion of some of these industries appears great. For example, Illinois, second only to Montana in recoverable coal, may one day see a marked increase in its mining operations.

Community services. In many rural areas, residents do not have easy access to quality health care, certain educational opportunities, police and fire protection, transportation, housing, and various welfare and social services. Often the deficiency can be traced to the distances involved in providing services and to the lack of citizens' knowledge about existing services and resources. The availability of public funding and the vitality of local leadership are also important, contributing factors.

Despite serious financial problems, rural elementary and high school districts generally provide good educa-

Consolidated school districts can offer educational opportunities that would be too costly for individual communities.

tional opportunities. Many school boards are considering the further consolidation of schools, a trend begun years ago. For interested families, private schools provide an alternative system of education in some communities.

Publicly supported community colleges enable young people and older residents to continue their education beyond high school in their home communities. The Illinois Cooperative Extension Service with its network of county offices and staff offers educational opportunities through programs in agriculture, home economics, youth, and community resource development. Regional universities also reach out with many services and educational programs.

Rural fire protection is highly dependent on volunteers. Money for up-to-date equipment and maintenance is a continuing concern in many communities. Between 1972 and 1980, crime in rural Illinois more than doubled, and tight budgets have adversely affected law enforcement agencies. It is encouraging, however, to see many examples of cooperation between citizens, community and farm organizations, businesses, and law enforcement officials in dealing with rural crime.

The need for more adequate emergency medical services and personnel, nursing homes, and out-patient care facilities is widespread. Contributing factors are the high proportion of the elderly in rural areas; occupational hazards in farming, mining, and forestry; and the lack of nearby major medical facilities.

Local government. The provision of public community facilities and services is, of course, directly tied to local and state governments; public education is a prime example. Other required services at the county level include law enforcement, the administration of justice, assessment and collection of taxes, recording of legal documents, conduct of elections, and construction and maintenance of roads and bridges. Counties may also provide public health and ambulance services, mental health care, garbage and trash disposal, certain agricultural services, and planning operations, to name only a few activities. Government oversees many regulatory functions as well.

Townships in Illinois spend most of their funds on general assistance, property tax assessment, and the maintenance of rural roads. The need for townships in highly urban areas has often been challenged, but rural people remain strongly supportive of their townships. Many are becoming involved in cooperative ventures with other governments to provide services.

Illinois, with its 102 counties and 1,436 townships, has the distinction of having more governmental units than does any other state. In 1977, the U.S. Bureau of the Census counted 6,620 units of government in Illinois, 5,522 of them with the power to levy property taxes. Between 1962 and 1977, two major trends occurred. First, the number of school districts decreased 31 percent because of consolidation. Second, the number of special districts that provide fire protection, water, and other specific services increased 29.5 percent.

Special districts have proliferated for many reasons. In some instances, special districts are virtually the only way rural residents can finance services or effectively participate in the management of them. Attempts are usually made to limit the use of special districts or to consolidate them to avoid confusion and overlapping of functions or territory, and to effect cost savings. Rural areas have an urgent need for intergovernmental cooperation and for sharing equipment and manpower to help cut costs and improve services.

Rural governments, including counties, townships, municipalities, and special districts, are facing difficult financial times. Costs of providing services have increased, while federal funding has decreased or programs have significantly changed. Revenues have also decreased, in many instances because of the poor economy, and citizens are generally resisting tax increases.

Like their urban counterparts, rural taxpayers usually do not clearly understand the operations of local governments, even though local public services are quite visible. One of the challenges to local officials and educational institutions is to provide citizenship education and opportunities for citizens to become more actively involved in local government.

Informal networks. Nonmetropolitan Illinois is a diverse but dynamic social, economic, and political system with close reciprocal ties to the metropolitan areas of the state. I have described some of the formal institutional situations and arrangements, but we should not minimize the informal networks of kinship, social groups, and community organizations that figure significantly in the day-to-day lives of rural residents.

Harvey J. Schweitzer, professor of rural sociology

The main streets in many small towns are no longer the hub of community life.

Farming Communities: Yesterday, Today, and Tomorrow

Sonya B. Salamon

As a way of life, farming has traditionally depended on the close ties between the family as a unit and the community as an extension of the family. In the past, the goals of the family and the values of the community reinforced each other, giving a wholeness to farm life. Now, however, the links between family and community have begun to weaken, and farm life is becoming fragmented. Our research among Illinois farming communities over the past eight years suggests that farm families will have to make a conscious effort to preserve their way of life in a rapidly changing rural world.

The unified past. Formerly, strong personal relationships and a long, shared history characterized farming communities. The values of the family were strengthened by the community's social institutions because farmers in a particular area often belonged to one ethnic group. Common goals, beliefs, and customs made for a continuity that was enhanced by the stability of the population. Elementary schools dotting the countryside were often staffed by women from local families or by outsiders who were likely to marry local farmers.

A central village was the hub of community life and contained stores that sold essentials, a bank, a grain elevator, a doctor, restaurant, and perhaps a high school. These local services were owned or operated by those who, like farmers, had made a life-long commitment to their jobs. Churches, too, were served by ministers who stayed for many years.

Farming made families relatively self-sufficient. Family members saw themselves as a team and felt they could control their own welfare. Although some children always left the farm, there were also always those who stayed, because families were large. These individuals maintained the traditions of the family and the community. It is true that the rural world was not arcadia — the individual paid the price of enforced conformity and too little privacy; but it is also true that the community's social institutions nurtured the family and therefore the individual.

The disruptive present. Today, farm families recognize that their way of life has changed radically. For one thing, the size of the rural family has declined (though not as dramatically as that of the urban family). Smaller families now produce fewer school children, consumers, patients, or clients for rural institutions. The number of family-owned-and-operated farms has also decreased as agriculture has changed.

Out-migration has coincided with a counter migration that has brought new rural dwellers with no local ties or community commitments. In some areas farmers have now become the minority population. Finally, nearby cities have expanded roadways and built more shopping malls, medical centers, and banks, all of which offer more competitive prices, services, and facilities than their rural counterparts.

The most obvious result of these changes is the loss of a vital village, a community locus. While conducting our research among Illinois families, we heard many comments on the recent death of towns, an event often associated with the closing of a school. School consolidation not only divided community children into competing school districts, it also disrupted former town-visiting patterns that supported local business. The closing of a school sensitive to the demands of the agricultural cycle and schedule meant that fewer children could participate in activities such as team sports and dances that united community families.

There were other, more subtle shifts in the patterns of farm family life. Farmers comment that "it used to be old folks would move into town; now they build a new home and stay out in the country." Villages

thus lost the retired farmers who were linked to rural households. These families had a vested interest in village issues concerning sewage, water, and government. Unlike those of the previous generation, the elderly now move into nursing homes located in the countryside but serving a far-flung population.

Farmers mourn the shifting patterns and complain that "people don't neighbor like they used to" and that "people don't know each other anymore. They go to different schools, live in different places, and watch TV. We used to visit our relatives on Sundays — that was the big thing."

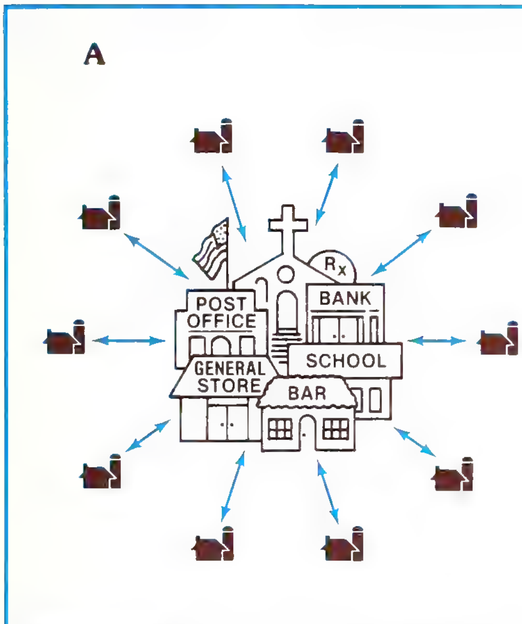
Even the church has lost its dominant position. Churches with diminishing membership have faced consolidations similar to those of the schools. Congregations must adjust to young, ambitious ministers who soon leave and to new members with no roots in the community.

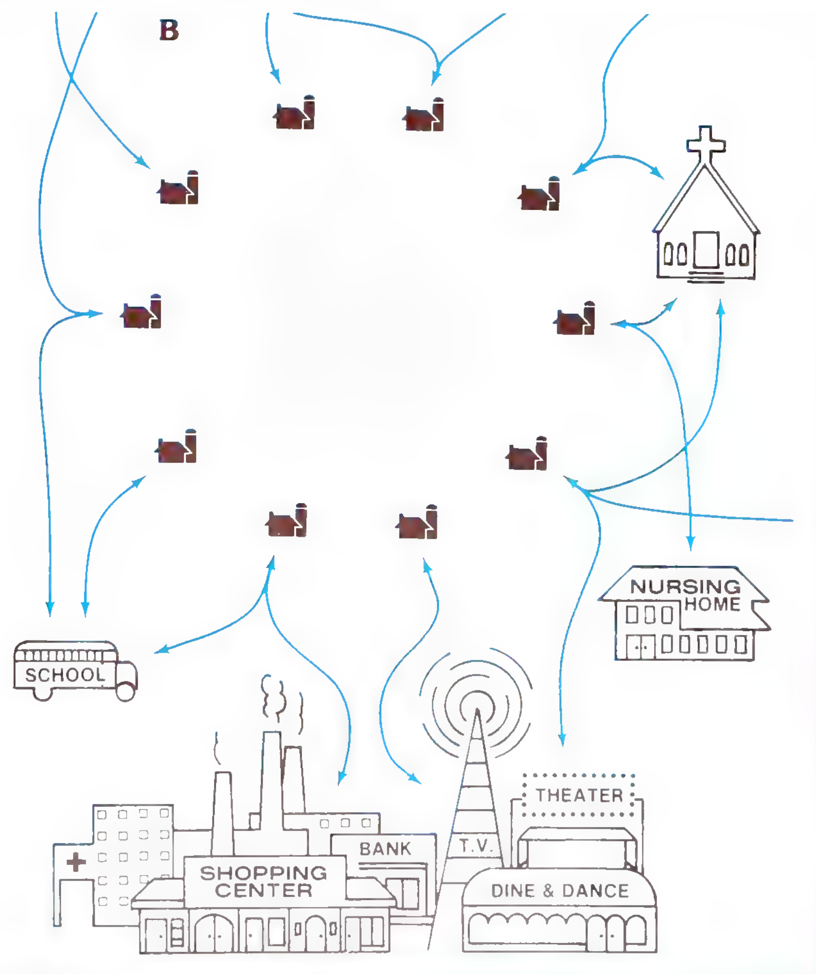
In response to transformations in agriculture and markets, family farming has become more of a business. External pressures, not the needs of the family, determine the type and size of the enterprise. "Farming isn't like it used to be. Hard work isn't enough now," remark older couples. They nostalgically recall the earlier, less specialized farm, where they raised various animals and where children had a variety of daily chores that "helped form character."

Because of the new demands on farmers (such as computerization), some higher education is viewed as a necessity. Often family members must seek off-farm employment to earn the capital required for the new farming. They frequently find themselves alone, driving great distances to maintain both family and farm. Farm families are losing the sense of belonging to and working as a team.

Divorce has further disrupted farm life. "When we got married there was no such thing as divorce — people just had to work it out," say older couples. The increased stress of modern life has led to a breakdown in the former patriarchal, authoritarian structure. Relations between the generations have altered. For financial reasons, fathers are reluctant to retire, and sons are anxious to make an independent start. Without as much support from an extended family and a well-known pastor, family members are forced, just as they are for shopping, education, and illness, to use urban social services. These services, though efficient, cannot give the personal support that rural institutions did.

Despite the vast changes, however, agriculture in Illinois is still a family enterprise and families struggle to maintain the quality of life they associate with farming.





The changing pattern of rural life.

A. Formerly, the family and the community sustained each other. Farm families were close-knit, working on the farm and involving themselves in the village, which in turn provided a support system.

B. Today, the links between the family and the community have weakened. Divorce, off-farm employment, urban services, and consolidation of churches and schools are forces that scatter individuals in different directions. The central core of community life has eroded.

What local solutions have emerged in response to the disruption? No single solution, certainly. But all agree on a prerequisite: the physical presence of certain symbols of community life — a restaurant or bar geared to agricultural hours, a small grocery store, a church with a committed leader, and a local school. This is the nucleus around which vital rural activities are clustered.

In addition, our research suggests that those communities that have kept their identity are those in which farmers continue to retire into town or are actively involved in local affairs. A farmer-village coalition seems essential for a thriving rural community. In one village that we studied, farmers united with townsfolk to rebuild a block of small businesses destroyed by fire. Their volunteer group has continued to make other improvements, such as the building of a playground.

Yet another strategy for survival has been to hold annual homecomings. Such occasions draw migrants back and strengthen bonds between farm families and their urban relatives.

The demanding future. Clearly, rural communities are beginning to see that they must make an effort to revitalize themselves. Earlier, when changes were seemingly small, farmers frequently shunned responsibility and action. Now they are increasingly aware of the dangers of inaction. The isolation and depersonalization that have defaced urban life have already invaded the rural world. The future could worsen the problems created by broken homes, loneliness, and depression. As rural institutions erode, families may direct their emotions inward with disproportionate intensity.

But the future could also bring regeneration. Farm families in the past were strong enough to endure the hardships of pioneering. Today they must be pioneers in another way — they must adapt to new agricultural demands in a fragmented society. They must weave the fabric of rural life with new fibers.

Sonya B. Salamon, associate professor of family relationships

Financing Community Services

David L. Chicoine

The current economic recession is creating hardships for public services in Illinois communities. Expenditures for services are generally slowing down, and real reductions may be under way. By analyzing the forces behind this trend, we can gain some insight into the tax and spending choices that face Illinois citizens and their elected officials.

Action and reaction. Beginning in the early 1970s, local government expenditures, adjusted for inflation, inched upward in Illinois at an annual average rate of 6 percent. But from 1979 to 1981, the rate of growth slowed to less than 2 percent. This recent trend contrasts sharply with the 1970s, when real per capita expenditures grew from \$410 in 1971 to \$555 in 1978. By 1981, real outlays stood at \$585 per capita. When available, data from 1982 and 1983 will probably show slow declines in real terms.

Expenditures reflect the demand for all local public services such as streets, public safety, police protection, local schools, and the like. Reducing expenditures on these and other community services is not unique to Illinois. All state and local governments in the United States cut back in 1982 for the fourth year in a row. Compared with many other states, however, Illinois has cut back more slowly. Between 1978 and 1981, combined state-local expenditures grew in real terms by 0.97 percent. Since local government outlays increased by 5 percent during this period, state government's share obviously had to decline.

Three situations have contributed to the slowdown in spending on community services: first, the forces of the recession, which limit local government revenues; second, the taxpayers' revolt, represented by the passage of Proposition 13 in California; and third, the radical shift in the flow of intergovernmental aid. The redirection of spending is not confined to particular services, units of government, or areas within the state, but cuts across sectors.

The fiscal shock of taxpayer unrest in 1978-79 was soon followed by a reduced flow of aid and by recessionary pressures. In Illinois, demand for lower taxes did not automatically result in externally imposed limitations on taxes and expenditures. Nevertheless, local policymakers received a powerful message: keep increases in public spending for community services in line with overall economic growth.

The message hit home, as the drop in the growth rate of expenditures shows. In addition, local and state taxpayers have had substantial tax relief. Tax increases proposed by state or local governments are now likely to signal attempts to keep basic services at the same level rather than indicate any real expansion in government spending and public services.

Much of the past growth in local expenditures was financed by growth in federal and state aid. By 1978, real federal aid to states and localities had reached \$231 per person annually. Beginning in 1979, however, federal aid began to decline and by 1982 had dropped to \$174 per person.

The squeeze on federal aid has been intensified by the growth in defense spending, major cuts in federal taxes, and an increase in the federal deficit. Lower levels of federal aid have affected both state and local

governments in Illinois. For nonwelfare state services, our state government received about $200 million less from Washington in 1982 than in 1981. Receipts for 1983 are expected to be still lower.

Shifts in state and federal aid are presented in Figure 1. In 1970-71, state and federal aid accounted for about 30 cents out of every dollar spent by local governments for services; 4 cents of this amount was federal aid. Aid grew until it represented 39 cents in 1973-74; since then it has been declining. The relative decline in funds from the state is the major force that has reduced intergovernmental aid to Illinois local governments thus far. By 1980-81, state aid to local governments, as a percent of expenditures, had dropped below the 1970-71 level.

State aid to local school districts is a prime example of the downward trend. Funding of local schools is generally considered the major responsibility of individual communities. Yet the state of Illinois spends a hefty 26 percent of General Fund appropriations on elementary and secondary education. During the last decade, these outlays have nearly doubled. The state's share of school costs rose from 37 percent in 1971-72 to a peak of 48.4 percent in 1975-76; since then it has been steadily declining. The 1981-82 percentage was just over 40.

During this ten-year period, expenditures per pupil grew in nominal terms from $1,733 to $3,062. Once price changes are considered, however, the expenditures in real terms actually declined about 20 percent in the last decade, to only $1,375 per pupil.

The weakened financial condition of our state government is the major cause of reductions in state aid for services in Illinois communities. Instead of a shift in spending policies, state decision makers have simply made do with limited state revenues. Illinois is in financial difficulty not because of spending in excess of revenues, but rather as a result of the state's depressed economy over the last three years, tax relief measures that substantially reduced state revenues, and declining federal support

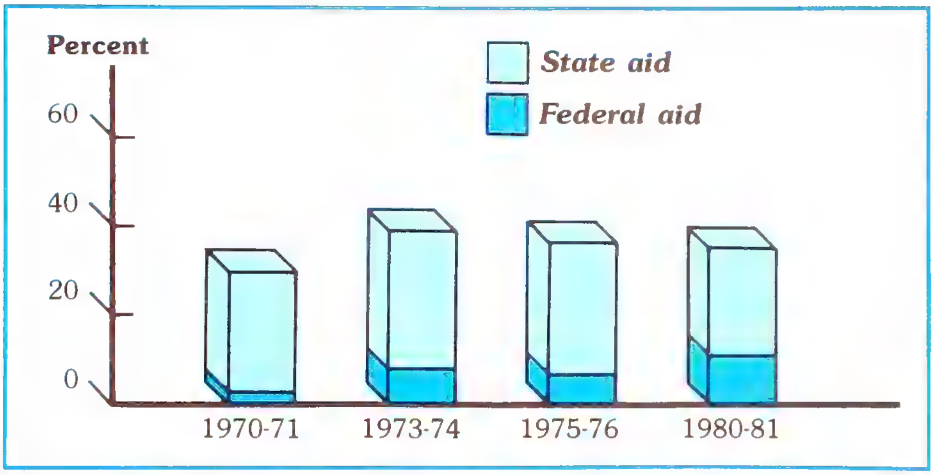


Figure 1. Intergovernmental aid as a percentage of expenditures by local governments in Illinois for selected years. In 1980-81, state aid was 24.7 percent of expenditures, compared with 25.7 percent in 1970-71.

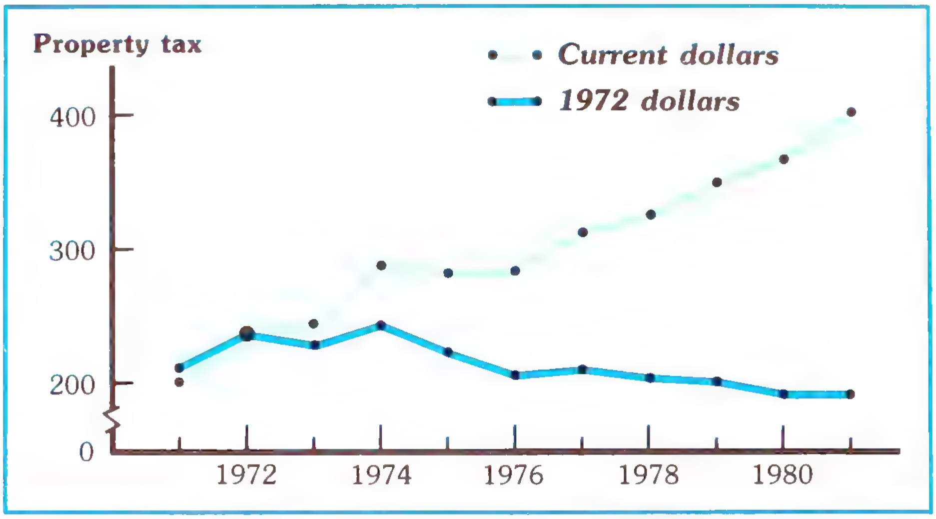


Figure 2. Per capita property taxes in Illinois, 1971 to 1981. Since 1974, real property taxes have declined steadily, although taxes in current dollars have continued to climb.

for state government services.

Without additional state revenues, the trend towards lower state aid for local public services probably won't reverse itself. In that event, local governments will have to adjust their levels of spending or use more of their own revenues to finance services.

The property tax. The major source of tax revenues for most local governments in Illinois is the property tax. Although suggestions to reform the tax or replace it with other sources of revenue have been under consideration for decades, the property tax remains the dominant source of local tax revenues, accounting for 77 percent of local tax receipts in 1980.

Two driving forces determine the level of property taxation in any community: the budgeted expenditures of local governments and the availability of other revenues for financing the budgets. Property tax needs are determined after spending levels are established and other revenues considered. Thus, if federal and state aid continue to decline, local policymakers will have to balance expenditures more closely against property tax receipts.

Through the late 1970s, a relative decrease in the real property tax burden accompanied the increased reliance on intergovernmental aid to finance community services (Fig. 2). Real property taxes per capita de-

clined continuously from 1974, reaching $192 in 1980. As a percentage of personal income, property taxes dropped from 5.1 percent in 1972 to 3.8 percent in 1981. These reductions resulted from property tax relief that generally narrowed the tax base, from the availability of intergovernmental aid to help finance service demands, and more recently from the general demands for lower taxes.

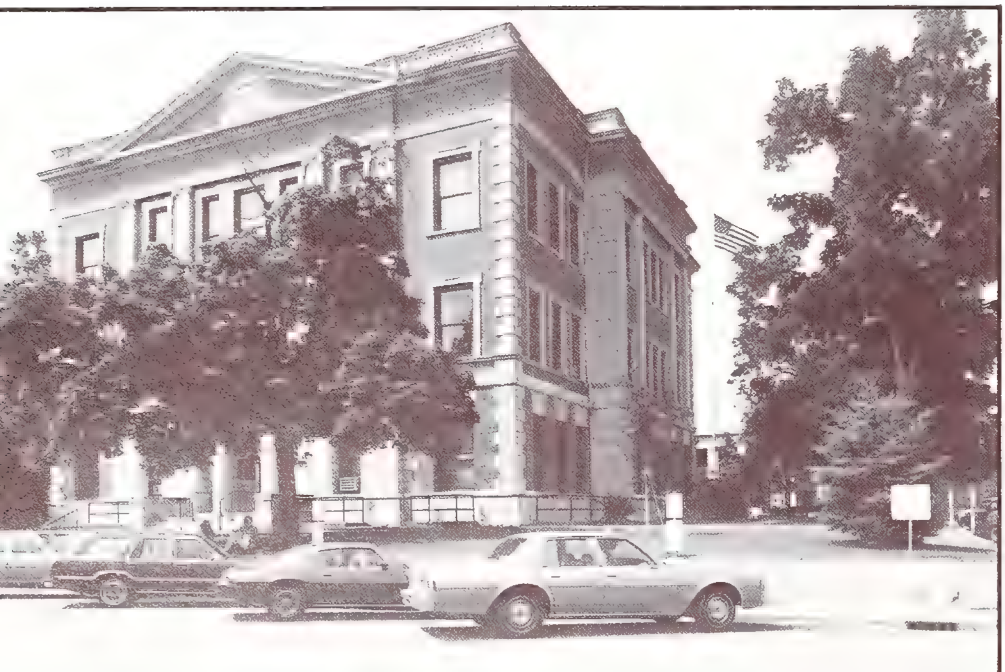
Currently, the 1981-82 decline in the housing market is working to reduce residential assessments. At the same time, poor economic conditions in agriculture and in the general economy are lowering assessments on farm and industrial properties. These reductions will contribute to the past trend of falling property tax burdens. However, the reductions in federal and state aid will put more pressure on the property tax, as the residual source of local revenue, to finance community services.

The pressure will not come from a single local government, but rather from the system of local decision-making units (municipalities, townships, school districts, counties, and special districts). Each unit independently determines service levels and property tax needs.

Immediate and future needs. The economic recession, reduced state and federal aid, and taxpayer unrest are causing a substantial shift in spending on community services. While the 1970s brought relatively lower property tax burdens, the pressure on the property tax is likely to increase in the near future if federal and state aid continue to fall. Weakened economic conditions will reverse the automatic revenue increases associated in the past with higher property assessments.

In the short run, many local governments in Illinois will have to tighten their belts a notch at a time as pressures for maintaining the level of real expenditures are countered by a general resistance to property tax increases. In the longer term, policymakers at both the state and local levels will be challenged to develop an acceptable system for financing local public services. The system will have to be fair and equitable yet stable. It will also have to be responsive to local needs for revenue and services yet administratively efficient.

David L. Chicoine, assistant professor of agricultural economics



Collectors' offices in county courthouses across Illinois tell a tale of declining property tax revenues in real dollars and rising costs of public services.

Land Uses, Values, and Taxes

John B. Braden

The most visible natural endowment of Illinois is its exceptionally fertile soil. Two-thirds of the state's land is used for crop cultivation, placing Illinois second among all states in the percentage of land devoted to crops.

This report focuses on two issues related to rural land that are of particular interest in 1983: declining prices for agricultural land and the special assessment program for taxing Illinois farmland.

Land use profile. First, let us review the patterns of land use in Illinois. Of the state's 35.7 million acres of land, 0.5 million are owned by the federal government. The remaining 35.2 million privately owned acres are distributed into several categories:

	million acres
Agriculture and forest	
Cropland	23.8
Pasture	3.1
Forest	3.0
Other	1.0
Urban and built-up areas	2.7
Rural transportation	0.8
Water and other nonfarm	0.7

Source: 1977 National Resource Inventories, the most recent comprehensive inventory of land uses available at the time of this writing. **Note:** 2.5 acres = 1 hectare.

Many rural residents have been alarmed by conversions of agricultural land to such uses as roads, residential subdivisions, and the like. In each of the years between 1967 and 1977, roughly 100,000 acres of Illinois land were affected, according to some federal studies and recent research by University of Illinois agricultural economists. This trend led Governor James Thompson in 1980 to proclaim a farmland protection policy.

Table 1. **Land Prices[a] in Illinois, 1960 to 1982**

Year	Returns to land	Average land price	Price-earnings ratio	Interest rate	Annual debt service amount	Percent of debt service paid by income
1960	$ 21	$ 550	26	6.0	$ 39	54
1961	23	535	22	5.6	37	64
1962	26	550	21	5.6	38	69
1963	29	580	20	5.6	40	72
1964	27	605	22	5.6	42	68
1965	30	650	21	5.6	45	67
1966	33	730	22	5.8	51	65
1967	29	775	26	6.0	56	52
1968	24	805	33	6.8	63	38
1969	30	830	27	7.8	72	42
1970	33	820	24	8.7	77	43
1971	34	825	24	7.9	72	42
1972	48	895	18	7.4	75	65
1973	85	995	12	7.5	84	100
1974	107	1,335	12	8.1	119	90
1975	80	1,610	20	8.7	152	52
1976	103	2,005	19	8.7	189	54
1977	89	2,720	31	8.5	253	35
1978	95	3,010	32	8.5	280	36
1979	110	3,400	31	9.2	336	32
1980	108	3,500	32	11.0	403	27
1981	93	3,605	39	12.8	476	20
1982 (prelim)	90	3,280	36	13.5	459	20

[a] Prices are per acre averages for land with productivity ratings from 86 to 100. This land is the most productive for corn and soybeans. The annual debt service presumes that all land costs are borrowed.

Source: Adapted from J. T. Scott, Jr. "Factors Affecting Land Price Decline: Where to From Here?" Department of Agricultural Economics Staff Paper No. 80 E-217, University of Illinois, June, 1982.

The future of rural land uses looks considerably more stable now. Economic stagnation, formation of fewer new households, slow rates of income and population growth in Illinois, and declining public service budgets all spell lower demand for new housing and commercial sites. Developed sites left vacant by population shifts and prolonged economic recession can accommodate much of the growth expected in the near future.

Land values. While the uses of rural land seem to be stabilizing, recent trends in land values are anything but stable. Since 1981, prices paid for agricultural land in Illinois have dropped (Table 1). A survey by the Federal Reserve Bank of Chicago revealed an average 20 percent drop between October, 1981, and October, 1982.

The broad drop-off in prices is the first of its kind since 1933, when very good land was available for less than $100 per acre. By the end of the 1970s, the long, uphill price climb out of the Great Depression reached the giddy heights of $4,000 per acre in some areas. At that level, the prices paid for farmland were seriously out of line with long-term productive returns.

Income generated by land used for production must suffice over time to repay ownership costs. As is evident in Table 1, the average price-earnings ratios for land purchased from 1977 to 1982 were at least 40 percent higher than for land purchased from 1960 to 1976. Farmers who borrowed extensively to buy land were hit with the double-whammy of high financing rates and high prices. The annual payment on an acre of land purchased in 1982 averaged $459, compared with the $37 to $152 on land bought between 1960 and 1975. Income averaged 61 percent of the annual payment for land obtained between 1960 and 1976, compared with 23 percent for land obtained between 1977 and 1982. By the late 1970s, a highly significant distortion had clearly taken place in the relationship between income-producing capacity and land prices.

The reorientation of prices to earnings has affected landowners in unequal ways. Cash grain areas have been hit the hardest; areas with vigorous livestock operations have suffered less. The disparity is a result of grain prices being unusually high relative to livestock prices in the 1970s and of grain prices having fallen considerably more than livestock prices in the last few years. With our high proportion of cash grain crops, Illinois land values have dropped more than in some other states.

Falling farmland prices breed reluctance to sell. In 1975, the number of cash sales involving 5 acres or more stood at about 4,500, rose to some 6,000 in 1977, and dropped to fewer than 3,900 by 1980. Since then, sales have continued at low levels. Foreclosures are up, primarily because landowners who were highly leveraged in 1977 or 1978 could not keep up their mortgage payments in 1981 and 1982.

The prospects for farmland values are unclear. Much will depend on whether commodity prices rebound. Government set-aside programs apparently have stabilized land values for now. In the long run, however, trends in farm income — the key determinant of rural land values —

are hard to foretell. An educated guess about future prices, crop yields, and interest rates suggests that an acre of good income-generating farmland is worth about $2,000, plus or minus a few hundred dollars, at present prices. Thus we may still be on the downward slope from the average price of $3,600 per acre recorded in 1981.

Farmland assessment. Quite clearly, the high price of land during the last decade created problems as well as opportunities for rural residents. One problem stemmed from a property tax system that was supposed to assess land at one-third of its fair market value. As values sped upward relative to farm income, farmers faced the possibility of climbing assessments and increasingly burdensome tax bills. If farmland prices increased more rapidly than prices of developed land, rural landowners would be forced to pay a higher proportion of the cost of services shared with town dwellers.

To avert some of these problems, Illinois adopted a differential assessment program in 1977. Farmland was to be assessed at its use value rather than at its market value. But many local assessors, by providing artificially low assessments, had already taken the bite out of the program. In 1973, 28 counties had median assessed values for farmland that approached the mandated one-third of the market value. Beginning in 1974, assessments increased at rates well below land prices. By 1976, all but one county's median assessed valuation ratio for farmland was less than 30 percent. More than half had median ratios below 20 percent.

The 1977 Act was followed in 1979 and 1981 by amendments intended to provide assessors with clear procedures to implement the preferential assessment program. The amendments were also intended to protect owners of lower quality land against paying proportionately more of their income for property taxes than owners of better land pay. Assisted by University agricultural economists, the Department of Revenue developed a system for relating assessments to the long-term net income expected from individual parcels of land. This system becomes fully effective in 1983, although through 1984 some counties will have a ceiling of $30 per acre on the rate at which an assessment can be raised in any one year.

Effects of the farmland assessment program have been very uneven. Only 38 counties decreased their average farmland assessment values from 1981 to 1982. The remaining 64 counties actually increased their assessments because many were assessing farmland well below one-third of the use value before the program became fully effective. In applying a clear-cut assessment formula under the program, assessors were forced to abandon an informal system that gave generous breaks to some landowners. Ironically, what is sometimes called the "Big Giveaway" program has actually increased the tax base in some areas.

Many local government officials feared that the preferential assessment program would seriously erode their tax bases — no small concern, since farmland accounts for more than 60 percent of the value of all property in some counties. The actual effects of the program have varied widely. In the many taxing units where assessed values were increased, the program has raised the tax base and afforded an opportunity to reduce tax rates. In jurisdictions where assessments were reduced, the revenue base has declined. Unless taxpayers accept measures to increase tax rates, the public services provided in those areas will have to be cut back.

Proportionate tax burdens may change considerably as a result of the program, but only where both farm and nonfarm property owners share the expense of costly public services. Public school costs are the largest single share of the property tax bill in most areas. Particular problems may therefore arise in regional school districts. In those taxing districts where farmland has been assessed below mandated preferential rates in the past, nonfarmland owners stand to pay a lower share of school costs. Relative to others, farmland owners will gain only in those districts where preferential assessments are below levels applied before the program's implementation.

One other problem stands out in the farmland assessment program. For assessment purposes, land values are set on the basis of past returns and do not allow for possible inflation in the future. However, interest rates used in computing future incomes do reflect inflation. The result is an underestimation of actual use values. In addition, assessments can change with the rate of inflation quite apart from changes in prices or productivity. Further revisions in the Illinois use-value assessment system may be needed to adjust for this problem.

John B. Braden, assistant professor of agricultural economics

Conversion of farmland to other uses, a source of concern to rural residents, has slowed down in recent years.

Freight Transportation Downstate

Robert J. Hauser

Come 1984, our transportation industry will have dodged the watchful eye of Big Brother. Indeed, recent federal legislation suggests that the 1980s are the time for transportation companies and their clientele to accept the risks, costs, and benefits of less governmental control.

With passage of the Motor Carrier Act and the Staggers Rail Act in 1980, many decisions about freight transport service and pricing have been shifted from the public sector to the private market. This laissez faire attitude has created some apprehension in rural communities.

Rail deregulation. When the deregulatory provisions of the Staggers Act were being formulated, people expressed many of the same fears of monopoly exploitation that led to federal regulation in 1887. Agricultural interests felt that deregulation would allow railroads to set unreasonably high rates in rural communities where little competition exists. Lobbying efforts did result in some constraints. If, for instance, a rate is set above a maximum level, a shipper may ask the Interstate Commerce Commission (ICC) to investigate. Nonetheless, railroads are allowed to set rates freely within a very wide range.

Two other important rate-making changes were made. First, a railroad now has considerable latitude in forming a private contract with an individual shipper. Second, the Staggers Act prohibits many collective rate-making actions that railroads used extensively to set rates in unison.

These reforms will have the largest impact on producers and merchandizers of grain (corn, wheat, and soybeans). The Illinois grain industry relies heavily on rail transport to Gulf and East Coast ports and to domestic feed markets in southern states. However, this reliance is mutual because grain traffic is necessary to the prosperity of most railroads originating shipments in Illinois.

Since deregulation, grain rail rates have been very responsive to supply and demand, and rates in general have decreased. Weak demand for export grain and record low barge rates have pushed export rail rates down. Fierce competition for domestic market shares is also occurring among railroads and between rail and truck, creating interesting rate wars for domestic-bound shipments.

Another ramification of free market rate setting has not been appreciated by grain shippers. Before the Staggers Act, rates changed once or twice per year. Now, however, rail rates for export grain change every two or three months, and domestic rates even more frequently.

The Staggers Act has also affected shipments requiring more than one rail line. Recently, a few railroads have avoided cooperating with each other in interline routing by increasing the charges for switching cars from another line to theirs or by simply refusing to offer combination rates. The ICC has not overruled many of these types of actions, to the dismay of shippers and some railroads.

The spirit of deregulation has also prevailed in rail-line abandonment decisions. In 1982, for example, the ICC approved 85 percent of the track mileage requested for abandonment. Although the criteria for approval did not change under the Staggers Act, the approval process was expedited and alternative procedural responses for shippers were modified. In addition, the Northeast Rail Act of 1981 granted special abandonment privileges to Conrail, an important carrier of grain eastbound from Illinois.

Rail adjustments. The deregulatory era is quite young, but it is already apparent that rail service and rate characteristics will be much more dynamic than in the past. To exploit this new regime fully, shippers will have to be more flexible in their marketing strategies and commit more resources to transportation management and distribution logistics.

Shippers must explore new markets and become more familiar with the way rail rates are set and offered. Railroads are very receptive to rate and service negotiations, and individual shippers can influence the rates offered to them if they are familiar with the costs and demands facing the carrier. Tariff provisions, private contracts, coordination among shippers, and many other factors should now be considered in assessing alternative rates and services.

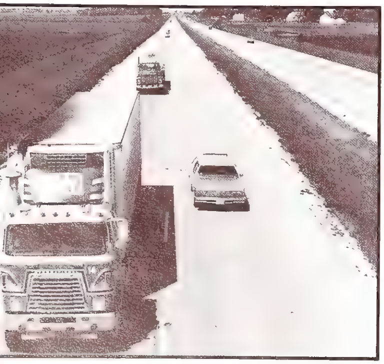
Shippers must also learn when and how to put up their guard. Rates and surcharges above the maximum level are not necessarily prohibited. Indeed, the ICC is not required to investigate any rate. Often the shipper must request an investigation and provide detailed evidence that the rate is unreasonable.

During the next few years, many shippers will be concerned primarily about the availability of service. Because of recent trends in abandonment and merger, some analysts believe that only four or five large,

main-line railroads will be running within twenty years and that short-line operations will become more attractive. Under the Staggers Act, any person may offer to buy or subsidize a line being proposed for abandonment if the offer is submitted within ten days after formal abandonment approval. But shippers contemplating the use of an abandoned line for a short-line railroad should keep two things in mind: first, the railroad abandoned the line because of inadequate profits, and second, the success rate of short-line operations has not been good. Yet despite the odds, a short-line railroad may be the solution to a shipper's problem once the factors determining the costs and benefits have been carefully projected.

Motor carrier deregulation. Although the ICC informally began some regulatory reforms in the 1970s, the Motor Carrier Act of 1980 formally reduced governmental controls established in 1935. The 1980 Act relaxes or eliminates controls on many agricultural commodities, but most raw commodities, including grain, were never regulated anyway. Thus rural communities may be affected differently than large cities because of location and population, not because of type of payload.

Proponents of truck regulation claim that it favors rural areas. According to this view, regulation has allowed motor carriers to provide high quality service to rural America at low rates primarily because profits from large community service help subsidize rural service.



Deregulation of the trucking industry, mandated by the Motor Carrier Act of 1980, has enabled carriers to expand their services to rural communities.

Rural areas have been protected by allowing only select firms to serve particular routes and markets and by ICC rate approval decisions. The 1980 Act relaxed these controls. Now, applicants do not have to provide as much evidence for service authorization, and a newly created zone of rate-making freedom encourages carriers to set rates independently rather than use the collective rate-making system. As a result, it is easy for existing carriers to get ICC permission to serve new clients and localities. Also, most rate proposals are approved. The trucking industry now operates in a very deregulated environment without the former benefits of cartel pricing.

The same type of deregulatory decisions are also being made at the state level for intrastate shipments. Compared with federal reforms, the deregulatory measures passed in some states are much more sweeping. Illinois will probably be considering such measures soon.

Virtually every study concludes that the service available to rural communities has clearly increased since deregulation and that the quality has not declined. Service has increased because those carriers already serving a community have been authorized to add other types of services.

The evidence for service charges is less clear. The real rate (adjusted for inflation) for all types of services and localities has decreased since 1980. But depending on measurement techniques, opinions vary on whether the average rate to small communities has increased or decreased. Regardless of the exact rate change, we have no evidence thus far of substantial increases in rates.

The rate pattern that seems to be evolving is based largely on economies of volume transported. Thus particular rural shippers or receivers may be at a disadvantage because of low-volume shipments and not because of a captive situation with no competition from other modes of transportation.

Motor carrier adjustments. Adjustments will depend on the willingness of users to understand and exploit the opportunities of the new system. A tremendous number of rate discounts in various forms are now offered, but shippers and receivers are often unaware of these tariff provisions. Discounts commonly reduce the rate by 10 to 15 percent and can usually be discovered with one or two phone calls.

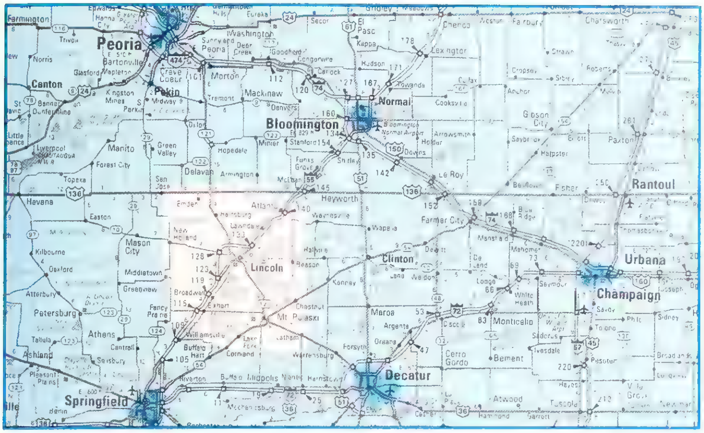
Another problem is that some users simply do not know what their transport charges are. The transport rate is frequently included in the price of transported goods, and the breakdown of costs on the bill of lading is often ignored or not recorded.

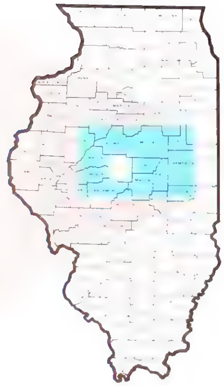
Independent businesses can also lower their rates by forming shipping associations or other types of alliances in order to coordinate large volume shipments. The key is being able to identify the great number of new alternatives now available to motor carrier users.

Concerns for the future. Deregulation of motor carriers and railroads has affected the rate and service structure of transportation in downstate Illinois. Up to now, however, the effects of deregulation have not matched the fears that existed when regulatory reforms were being proposed. Still, many transport users are anxious because of the possibility that deregulation will lead to a transportation industry comprised of a very few large companies capable of reducing marketing alternatives and increasing rates to monopolistic levels. Users also fear that service will be poor and that rates will be inequitably high after current economic conditions change. Deregulation will have to be around a long time and be carefully studied before we can judge whether these fears are warranted.

Regardless of what happens, users must become fully aware of changing opportunities. A free market system may offer many benefits to shippers and receivers who are willing to learn and adapt to free market forces.

Robert J. Hauser, assistant professor of agricultural economics





Self Help: Logan County Takes Action

Jerry W. Robinson, Jr., and J. C. van Es

"We're the hole in the doughnut economically, but we could be the hub in the wheel, especially when it comes to quality of life." That's the way one resident summed up Logan County's problems and aspirations.

Sitting in the middle of Illinois, Logan is a nonmetropolitan county with nearly 32,000 residents, half of whom live in the small city of Lincoln. Despite the county's vigorous agricultural base, problems abound, among them, strong economic competition from cities nearby but outside the county, scarcity of jobs for young people, and loss of state-supported services. Yet instead of giving up, Logan County residents have decided to help themselves.

Leadership Involvement

The first push towards self help came when the Cooperative Extension Service adviser in agriculture was looking around for educational and consulting services to help agribusinesses in the area. One member of the Agricultural Council sidetracked the search with the comment, "While we have problems with agribusiness in Logan County, we have other problems that are more important. We need to do something to broaden the economic base of this county."

With help from the Extension adviser and two rural sociologists from the Department of Agricultural Economics, the Agricultural Council attacked the problem by setting up an informal study group to discuss some of the critical issues. The group's findings led to the establishment of the Logan County Community Resource Development (CRD) Council in February, 1980. Members were nominated from every town, village, and area of business in the county.

The CRD Council spelled out three objectives for itself: "To make Logan County a better area in which to live and do business; to serve, as needed, as a symbol of pride in Logan County; and to encourage a team effort from every part of Logan County to accomplish our mutual goals."

During council meetings additional employment emerged as a paramount concern. Many residents were leaving. Others were commuting to work in Pekin, Peoria, Morton, Bloomington, Decatur, Champaign, and Springfield. Surrounded by these major employment centers, Logan County had become the "hole in the doughnut." But how had it happened? Did local inaction indicate that many residents were content with the lack of expansion in the work force? How did residents, both adults and young people, feel about the county and its future?

Community Analysis

Survey of community needs. With our assistance, the CRD Council developed a questionnaire to study how satisifed the residents were with the community and what they thought could be done to improve it. Adults selected by random sample were interviewed, as well as all 1980 graduates of every Logan County high school, thus providing two different but equally important points of view.

Local newspapers and radio stations publicized the survey beforehand and explained its purpose. A team of 25 residents then distributed the questionnaires to the adult sample and collected 450 forms a few days later. The graduates were interviewed at school during the last week of classes. Staff members in the Department of Agricultural Economics coded, tabulated, and analyzed the data. Both surveys called for real team efforts.

Several important facts came to light:

- Tremendous support existed for the kind of economic development that would create jobs. People wanted action, not inaction.
- High school graduates going away to college wanted to return to the county to live and work, but stated

Removal of parking meters was the first step in improving the streets and businesses surrounding the town square in the small city of Lincoln, Illinois.

they could not because appropriate jobs were unavailable.

- The graduates were probably more realistic than the adults in assessing various development options such as tourism for strengthening the county's economic base. Adults tended to overrate benefits from the tourist industry.

Development in other communities. Someone suggested that study tours might be a valuable way for council members to learn how other rural communities are making things happen. The idea caught on quickly. Support was obtained from town and village councils, the County Board, the Lincoln Chamber of Commerce, and the Cooperative Extension Service. A three-day tour, carefully planned for late summer of 1980, included southern Illinois and several rural counties in Mississippi.

Six council members were recruited for the trip and agreed to give time after the tour to tell others what they had learned. One tour member was designated the photographer. What some people thought might be a vacation became a very intense learning experience. As one member said, "This trip did more than any experience I have had to open my eyes to what can be done in community development when rural and urban folks in a county work together." The stage was now set for reporting and planning for action.

Community Action

Results of the survey were printed by local newspapers in a special supplement and mailed to every boxholder in the county. Radio stations helped get the word out that residents wanted change. And furthermore, they were willing to work and pay for it!

A slide set with a lecture tape and background music was prepared to describe what council members learned on the tour. All told, they attended some 50 meetings and spoke to more than 2,000 people. In special reports to the organizations that helped finance the trip, tour members explained how communities with fewer resources than their own were making improvements. The CRD Council had become a catalyst for change: the wheels were turning.

Parking meters. Like many towns, Lincoln was faced with downtown shopping problems, partly because parking at a new shopping mall on the edge of town was free. Many shoppers did not like the downtown parking meters, but previous efforts to remove them had failed. Armed with data from the survey, the CRD Council finally persuaded the Lincoln City Council to get rid of the meters. A symbol of success, removal of the meters gave the CRD Council and other community leaders confidence.

Economic development plan. In October, 1980, the County Board asked the CRD Council to serve as the official Logan County Economic Development Council. Members of the new Council, who were now wearing two hats, developed a comprehensive plan, which was approved by the County Board and subsequently submitted to the U.S. Department of Commerce in Washington, D.C. Approved in February, 1981, this plan enables the county to qualify for federal funding to solve development problems. Without an approved plan, participation in Economic Development Administration programs is impossible.

Chamber of Commerce. Before the study tour, each town had its own Chamber of Commerce, with Lincoln's being oriented primarily towards its own business and industry. During the tour and survey, members of the CRD Council recognized the need for a countywide group concerned with all types of business, development, and other problems.

Special committees appointed to look into the matter soon reorganized the Lincoln Chamber into the Greater Lincoln Area Chamber of Commerce. Restructured to reflect the needs of the entire county, the Chamber Board now includes members from all towns and villages, and farmers as well. After a national search, a full-time executive director was hired.

Development foundation. Because the good community organizes to solve its problems, the Council and Chamber led the way in establishing the Logan County Development Foundation (LCDF) and in obtaining a charter for it. A private nonprofit corporation, the Foundation is made up of members from throughout Logan County. Its goal is to support local efforts to attract new jobs. The LCDF Board of Directors includes ex officio members from the Atlanta Industrial Development Corporation, the Greater Lincoln Area Chamber of Commerce, the Mt. Pulaski Chamber of Commerce, the Community Resource Development Council, and the Logan County Regional Planning Commission.

The Foundation is a voluntary organization that brings together community-minded people and uses their ideas and talents to help improve the local economy. No pay is received for these efforts. Anyone may join the Foundation by making a pledge or by belonging to a local business association. Members elect new directors from the membership at the annual meeting in October. The Board of Directors in turn selects officers and governs LCDF affairs.

In 1982 the Foundation obtained $30,000 in support from the town and city councils and from the County Board. Citizens pledged to donate another $130,000 over the next ten years and volunteered countless hours of valuable time.

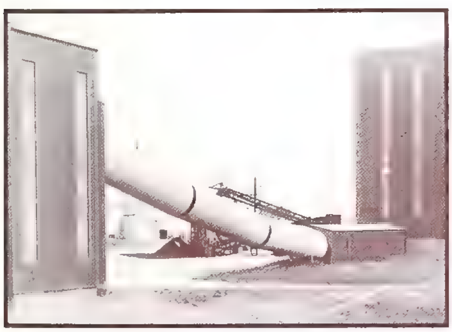
One primary purpose is to establish industrial sites near Atlanta, Lincoln, and Mt. Pulaski. On one of those sites, a general purpose building will be built to serve as an "industrial incubator." This structure will accommodate one or more expanding businesses that may lease space to test-market their products without risking a large capital investment. When successful, the businesses can put up their own buildings in the area.

New jobs and industrial sites. Two years ago special efforts were made to encourage employees hired by a new subsurface coal mine at Elkhart to make Logan County their home. Last year an insurance company, recruited by a group of local citizens, established a regional office in Logan County. The company opened with 200 employees and hopes to expand to 400 in the next few years.

Also in 1982 the process of locating potential sites for industrial development began. No easy task, the process is often ladened with conflict of values and interests. Impact studies must be made, and problems related to drainage, waste, transportation, and energy must be considered. One site near Atlanta has been approved. Negotiations to purchase it are under way between the owners and the Logan County Development Foundation. Sites near Mt. Pulaski and Lincoln are now being explored.

The Economy Fire and Casualty Company built this regional office on the outskirts of Lincoln. The company hopes to employ four hundred people eventually.

Photos courtesy of John Fulton



Construction and operation of the Turris Coal Mine, located near Elkhart in southern Logan County, brought dozens of new jobs to the area.

Workshops and shopping survey. During 1982 the Chamber and the Council working with the Cooperative Extension Service held a leadership development seminar; more than 30 local business leaders participated. A one-day seminar on marketing and advertising for small business is planned for next year.

Last summer we helped the Community Resource Development Council to conduct an innovative survey designed to identify shopping patterns of Logan County residents. According to the survey, which covered clothing, automobiles, furniture, and appliances, Logan County may "lose" nearly $4 million annually because many residents purchase these items outside the county. Local businesses are now being encouraged to go after a larger share of the retail market. The marketing seminar and these follow-up activities are an outgrowth of the survey.

Current Problems

Many challenges still lie ahead in Logan County. In the near future attention will need to be concentrated on several issues:

- Proving to farmers and small-town residents that the Logan County Development Foundation and the Greater Lincoln Area Chamber of Commerce have a truly countywide focus and will not gobble up or ignore small towns.
- Maintaining the Chamber's dues structure, which is higher than small-town people expect to pay.
- Sustaining interest in industrial development, a difficult task in light of the long-term process of evaluating and establishing suitable sites.
- Dealing with the conflicts that are likely to occur as change continues.
- Preparing buildings on industrial sites and recruiting employers.

For its 1983 banquet, the Greater Lincoln Area Chamber of Commerce chose the theme "Meeting the challenge of tomorrow: if it is to be, it is up to me in 1983." People in Logan County are beginning to believe they can shape their own destiny.

Jerry W. Robinson, Jr., and J. C. van Es, professors of rural sociology

Update

A Unique Policy Opportunity

Robert G. F. Spitze

Public policy is continually being revised to better serve society. Now, as the 1985 termination date for the Agriculture and Food Act of 1981 approaches, we have another opportunity to make significant changes. In the past, several overlapping problems related to cropland have fostered separate policy developments focused in three areas:

- production balancing
- conservation
- stream water quality

This critique explores the opportunity for integrating the three.

Public policy represents a compromise reached among many private interests about some societal problem and embodies a mixture of economic, political, and social objectives. Farm homesteading and the land grant educational system are examples of the many policies that have evolved over two centuries. Some are inconsistent. Subsequent policies frequently become more comprehensive and include several different previous public actions. For example, under the omnibus acts of 1977 and 1981 previous policies concerned with farm production, prices, and incomes were combined with those about food reserves, domestic and foreign food distribution, and trade. The right combination of separate policies can improve efficiency in the use of public resources and better resolve societal problems.

Three Public Policies

Over the past 50 years, separate policies, sometimes administered by the same agency, have evolved for production balancing, conservation, and water quality. Public inducements are now offered by each policy to achieve voluntary, private performance, in contrast to the usual techniques of licensing, regulation, restriction, and so forth. Since each of the three policies concerns land for crop farming, their integration may be possible. But first let us review these policies.

Production balancing. A policy of production balancing or control for crops has existed since the 1933 AAA, when the supply relative to the domestic and foreign demand was excessive. Although continuously authorized, production balancing has been used only when an imbalance between supply and demand is problematic for farmers or consumers.

In the early decades of the policy, acreage and marketing controls were compulsory, following a favorable farmer referendum. As the policy evolved, however, the techniques shifted almost exclusively to voluntary participation. The public inducements used have included access to price supports and the farmer-owned grain reserve, diversion and long-term soil-bank payments, deficiency payments keyed to target prices, and most recently payment in kind (PIK). In turn, farmers have been required to reduce soil-depleting crops, conform to acreage allotments, and set land aside for conservation use.

At present the Agricultural Stabilization and Conservation Service (ASCS) administers the policy. Substantial Treasury outlays currently go to 57 percent of all farmers with feed grain bases (corn and sorghum), provided they reduce approximately 40 percent of their recently harvested cropland. For all crops, the total withdrawal of about 80 million acres represents 8 percent of all farmland. Inducements, either cash or products, can exceed $200 per retired acre, depending on yields and degree of participation.

To qualify, producers must seed a cover crop or leave corn stubble undisturbed. A limit of 50 percent is set for retired land in each county to avoid too great an economic impact on communities with less productive and higher risk land. Erodibility or contribution to stream sediment is not taken into account. The policy is not primarily designed to channel public inducements toward any objective other than reducing the supply.

Soil conservation. Also since 1933, public policy has directly affected practices related to erosion of farmland. This policy is administered through the Soil Conservation Service (SCS, codified in 1935) and programs initiated by the Soil Conservation and Domestic Allotment Act of 1936.

In the subsequent evolution of soil conservation policy, assistance in technical planning has been offered as an inducement to individual cooperating farmers and to entire watersheds. Local Soil and Water Conservation Districts (SWCD) provide this service, and local offices of ASCS offer cost-sharing agricultural conservation payments (ACP) — another form of inducement — to a limited number of farmers for specified conservation practices. Soil conservation policy has always been voluntary, except in those watersheds where referenda confer additional powers of enforcement.

Initially the ACP program was used indirectly for production control by reducing soil-depleting crops. In recent decades, however, neither this nor the SCS program has focused on production balancing. The primary purpose has been to increase conservation practices directly, or indirectly by supplementing net farm income.

Soil conservation policy grew out of public concern about the soil base for future generations, dramatic water and wind erosion, and shifts of prime farmland to nonfarm uses. There was concern about whether private interests can make adequate economic decisions for preserving vital farmland.

The ACP policy currently affects 13 million acres of farmland (1.3 percent of all land in farms) on 245,000 farms

(10 percent of the total) with an annual expenditure of $200 million. The SCS policy has affected a cumulative total of 620 million acres (60 percent of all land in farms) on 2 million farms (80 percent of the total). An annual expenditure of $600 million comes from local, state, and federal sources. These per acre expenditures are much lower than under the production-balancing policy.

Soil conservation policies indeed tend to result in less intensive cropping on the most erodible farmland, and hence in less production and sedimentation. By the same token, they tend to increase farm output over the long term by land investment and economic land use. Yet the public inducements involved were not designed with any objective other than conservation in mind.

Quality of stream water. This country's general environmental policy was launched with the comprehensive Environmental Protection Act of 1969-70. The Federal Water Pollution Control Act of 1972, as part of the policy's evolution, then focused on the major contribution of farmland to non-point sources of waterway pollution from sediment and chemicals. Section 208 of that Act mandated that states develop programs to make stream water swimmable and fishable by the mid 1980s.

Deadlines have been eased, and this new policy is still being shaped in response to public concern about the environmental quality of stream water. The policy emphasizes comprehensive land use planning, state and local direction, and best management practices. An estimated 50 percent of the sediment entering waterways originates on farmland, and 64 percent of all cropland contributes to the pollution.

The water quality policy is now in the final planning and approval stage. A few states use mandatory compliance, but most are using various inducements to attract voluntary compliance. Federal funds for that purpose are not provided and little state funding is available. Other inducements include educational and technical assistance, the monitoring of sediment-producing erosion, and persuasion through hearings and peer reprimand.

Illinois adopted a plan calling for the lowering of soil loss on all farmland from maxima of 20 tons to 5 tons per acre in successive stages until the year 2000. An estimated 40 percent of the state's agricultural land currently exceeds the tolerance limit. The SWCDs and the Illinois Department of Agriculture are administrators.

As this policy dealing with non-point waterway pollution develops, it may eventually affect half of all agricultural land. For now, the policy relies largely on voluntary compliance but with little or no funding for financial inducements.

Opportunities for Policy and Research

These three public policies which someday will affect virtually all cropland, have evolved for the most part independently of each other over the past half century. A research base has also developed, but it, too, is often directed to the differentiated problems. The agencies tapped — ASCS, SCS, and relevant state agencies — to implement the policies have certain similarities. Relying almost exclusively on voluntary compliance, each agency uses education, technical assistance, persuasion, and payments as inducements. Where private economic decisions are concerned, financial inducement is paramount. Yet funds have been a severe limitation except for the production-balancing policy.

The next two years offers the public a rare opportunity to consider an alternative that focuses simultaneously on all three policy problems. With the water quality policy only now taking form, this is the first time we can bring together policy objectives, provisions, and accomplishments.

Convergence of the policies may answer the public's demand for improvements in these problem areas and may also help cut costs of public services. Agencies and programs might be combined, public funding targeted for multi-purpose activities, and farmers given a chance for simultaneously assessing land use options and inducements.

Under such an alternative, the major inducements, as change instruments, would probably be information, technical assistance, and monetary payment. These could be coordinated. Higher payments generally induce greater compliance. Payments could therefore be scheduled according to the degree that a parcel of land contributes to all three problems. Thus the more highly productive, erodible land nearest the water channels might be indexed for the highest payments, and the less productive, level land farthest from streams indexed for the lowest payments.

The public could "lease" substantial greenbelts adjacent to streams and the more highly erodible land until their productive capacity was needed for national purposes. The more erodible the land, the longer the term of "lease" and the higher the payment. Livestock grazing could be permitted to lower the payments even though it might add to total agricultural production.

An integrated approach would probably require a larger outlay relative to any one of the separate goals, but it should lower the total outlay for all three policy goals. This approach would of course have to reconcile the impacts on land values, windfall gains and losses to landowners, and the economic bases of communities.

Research could also be called into play to give policymakers the information needed for assessing this policy opportunity. Indexes of farmland attributes contributing to the problems could be constructed. Researchers could assess the responses of farmland owners to schedules of inducement payments geared to these indexes. In addition, researchers could identify the demand priorities of the public and its willingness to supply the support for the combined policies.

Only a sketch of existing policies and the opportunity for policy change has been given here. The opportunity includes integration of these three land use policies along with other alternatives.

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